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# UTILITY-FOCUSED MARKET MODEL FOR ZERO ENERGY NEW HOMES

*Prepared For:*  
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*Managed By:*  
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## Preface

The California Energy Commission's PIER Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the Commission, annually awards up to \$62 million to conduct the most promising public interest energy research by partnering with research, development, and demonstration organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Buildings Energy Efficiency End Use
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Energy Systems Integration
- Energy Innovations
- Transportation

*Utility-Focused Market Model for Zero Energy New Homes* is the final report for the project of the same name (Contract Number 500-04-024) conducted by Architectural Energy Corporation (AEC). The information from this project contributes to PIER's Buildings End-Use Energy Efficiency Program.

For more information about the PIER Program, please visit the Energy Commission's website at [www.energy.ca.gov/research/](http://www.energy.ca.gov/research/) or contact the Energy Commission at 916-654-4878.



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## Abstract

In 2004, the California Energy Commission's Public Interest Energy Research (PIER) Program initiated a Zero Energy New Homes Research Program to help address California's critical issue of growing energy use and demand. The program objectives included finding ways to reduce summer peak electricity demand from an entire neighborhood of at least 75 new homes using beyond-code energy efficiency measures paired with rooftop electricity production from solar photovoltaic systems. One of the projects funded by this program is the Utility-Focused Market Model for Zero Energy New Homes.

The project's goals were to evaluate sustainable market models for building new zero energy, single-family homes; to better understand the role of energy utilities in these endeavors; and to determine the effects of neighborhoods that need very little grid electricity on the local electric grid infrastructure. Because of a crisis in the housing and mortgage industries that severely affected the new-home construction market, many of the project tasks were left incomplete by mutual agreement. Key findings include the following:

- Home builders who constructed new homes under Zero Energy Home programs felt their reputations were enhanced by the experience. Marketing and media exposure contributed to homes sales, and the homes sold as competitively as conventional homes.
- There is a need for educating people shopping for new homes, at least in some communities, on the energy efficiency features of homes and on solar energy systems.
- Reducing the electricity demand of relatively large single-family homes in a hot climate to only one kilowatt per hour, especially during the local utility's summer peaks, is an enormous challenge.
- Early design and better integration of energy efficiency into home designs are crucial for achieving zero energy or near-zero energy.
- When optimized homes are built to a higher standard, builders and contractors experience fewer callback problems.
- California may be losing opportunities to create more sustainable homes and communities by not having many incentive programs for encouraging such development at the very early land entitlement phase.

**Keywords:** Zero Energy New Homes, ZENH, Zero Energy Homes, ZEH, Zero Energy New Homes Market Models, Utility Models for Zero Energy Homes, solar, photovoltaic, energy efficiency, Title 24, New Solar Homes Partnership, Utility Zero Energy Homes



## Executive Summary

California has an increasing problem with the costs of and ability to provide electrical power during peak-demand periods that occur on hot summer days. The population in California is increasing, and builders have responded by constructing more homes. The California Building Energy Efficiency Standards (Title 24, Part 6 of the California Code of Regulations, the state's energy code) sets the minimum requirements for energy efficiency for new residential construction, creating the baseline for expected energy performance. Further efficiencies are possible through increasing insulation, addressing air leakage, and selecting high-performance windows, lighting, and heating, ventilation, and air-conditioning equipment. In addition, solar electricity (photovoltaic) systems added to new homes can further offset energy use and demand by harnessing the sun to make electricity during peak summer periods and throughout the year.

In 2004, the California Energy Commission solicited proposals for a Zero Energy New Homes research program, which resulted in the following funded projects:

- Commercializing Zero Energy Home New Communities, Powerlight Corporation
- Affordable Multi-Family ZENH Project, Global Green USA
- Utility-Focused Market Model for Zero Energy New Homes, Architectural Energy Corporation (AEC)

Though the Commission's Zero Energy New Homes program goals did not focus on a truly zero-energy house, which is a home that combines enough energy efficiency and on-site electricity generation to offset the amount of electricity purchased from the utility grid, the program set the following ambitious performance goals:

- Improve building energy performance by at least 25 percent over the 2005 Title 24 Energy Standards.
- Reduce summer peak demand to no more than one kilowatt per hour per housing unit.
- Reduce the homebuyer's incremental first cost for a Zero Energy New Home to no more than \$5,000.
- Reduce annual electricity bills by 70 percent.

The greater policy objective was to make Zero Energy New Homes a mainstream part of new home construction in California.

The goal of this specific project, Utility-Focused Market Model for Zero Energy New Homes, was to develop sustainable business models that included the design, construction, financing, and ownership of new homes that substantially lowered the homes' energy use and electricity draw from the grid. One major focus of this project, which began in 2005, was to evaluate possible supporting roles for utilities. Another important aspect was the design, construction, and monitoring of a demonstration community of 75 optimized homes and comparing their energy performance to a neighboring Title 24 baseline community. The project team sought builders and solar energy companies as partners.

For two years, the slow housing market coupled with subprime lending and mortgage issues drastically affected the project team's ability to find a committed builder. Several builders joined and then left the project. In late spring 2007 the project team found K Street East LLC and worked with K Street's team on a 41-home community, named O Bel Sole, in Lancaster, California. Construction and sales of new homes in Southern California continued to drag, particularly in Lancaster. O Bel Sole recorded only two home sales in one year. The Architectural Energy Corporation project team was unable to move forward without completed and owner-occupied homes. In a mutual agreement with the Energy Commission, Architectural Energy Corporation terminated the project in late summer 2008 with incomplete activities.

In addition to the mortgage crisis, a complicating factor was the onset of California's New Solar Homes Partnership in early 2007. New Solar Homes Partnership began offering rebates on photovoltaic for new homes that were 15 and 35 percent better on energy efficiency than homes built just to Title 24 energy standards. PIER's Zero Energy New Homes goal was to reach 25 percent better than Title 24, and K Street planned for this goal. New Solar Homes Partnership added confusion to the already-suffering new homes market for K Street and increased K Street's challenge to sell homes in O Bel Sole.

In summary, Architectural Energy Corporation's team completed the following key project tasks:

- The project team analyzed the builder-partner's home designs using both Micropas and DOE-2 energy modeling programs and provided feedback to the builder. The builder enhanced the homes' energy efficiency measures (insulation, windows, radiant barrier, and space heating and cooling). The team also provided input about the photovoltaic systems' orientation and size and calculated summer peak demand loads.
- The project team analyzed the model homes' anticipated energy use using Southern California Edison's time-of-use rate tariffs.
- The team developed sales and contractor training material and conducted several training workshops for real estate sales staff and building contractors.
- The team developed a monitoring plan to measure end-use loads.
- Southern California Edison established the plan for distribution branch-circuit monitoring of the project homes and comparison homes in a conventional subdivision.
- The team conducted research to provide a better understanding of 1) the land entitlement process, defined as predevelopment activities involving the submittal of plans to city, county, state, and federal governments to secure approvals and permits to develop a property for a desired use; and 2) the potential for this process to strongly encourage the design and construction of sustainable homes and communities via existing and new incentives. The process of entitling land is a long and often complex part of a larger land planning and developing process and precedes actual physical construction. Most existing incentive programs reward aspects of actual construction (such as state rebates for photovoltaic systems) and come much later than land entitlement, and they are typically given to the builder or homeowner, not the developer. One task report, *The Land Entitlement Process and Incentives for Sustainable Communities*, describes the entitlement process, lists existing developer incentives, and includes developers' wished-for incentives. The report recommends that the Energy Commission form an advisory committee of key stakeholders to implement

further incentives for sustainable communities during entitlement. This report should be available through the Energy Commission at [www.energy.ca.gov/2009publications/CEC-500-2009-089](http://www.energy.ca.gov/2009publications/CEC-500-2009-089).



## 1.0 Introduction

The long-term goal of the California Energy Commission Zero Energy New Homes (ZENH) program was to create house designs that met the performance goals shown in Table 1. Although the Commission's ZENH program goals did not focus on a truly zero energy house, which is a home that supplies enough energy annually to offset the amount of electricity purchased from the utility grid, the program set ambitious performance goals that focused on other key factors such as cost and peak demand.

**Table 1. Energy Commission's ZENH program goals**

Target	Characteristics	Calendar Year		
		2005	2008	2013
Energy	Percentage exceeding energy efficiency levels in 2005 Title 24	25%	35%	45%
Peak Demand	Total electricity peak demand per house during summer peak	1 kW	0.5 kW	0 kW
Cost	Incremental first cost	\$5,000	\$2,500	\$0
	Annual electric bill savings	70%	85%	100%

Source: Architectural Energy Corporation

This project, called Utility-Focused Market Model for Zero Energy New Homes, began with a California Energy Efficiency Building Standards (Title 24) base case design that is enhanced with energy-efficient features plus a photovoltaic (PV) system to generate electricity onsite. The overarching goal of this project was to develop a sustainable market model for building ZENHs. The PIER project team had hoped to create a larger role for electric utilities in marketing these innovative types of homes.

The project included many stakeholders in the home building process. The core project team consisted of AEC, Southern California Edison (SCE), Consol, Geltz Communication, and Consumer Powerline. Key partners involved in this project during various stages included Pulte Homes, Pardee Homes, Clarum Homes, K Street East LLC, Byrne & Byrne Builders, Sharp Solar, and SunPower Corporation.

### 1.1. Background

California and the United States in general have an increasing problem with the costs and ability to provide electrical power during peak-demand periods that occur on hot summer days. The population in California is increasing, and builders are constructing homes to accommodate the demand for new residences. Title 24 sets the minimum standard for the energy efficiency of new residential construction, which is the baseline for the performance of new homes.

The U.S. Department of Energy (DOE), through its Building America program,<sup>1</sup> has been promoting the concept of Zero Energy Homes (ZEH). These homes are highly efficient, exceeding the Title 24 baseline, and utilize PV systems to generate electricity. The Building America work focuses primarily on development and integration of technologies into ZEHs, development of rate structures to promote demand response, and development of controls to implement demand response. These activities focus on creating technology, rather than creating markets. This PIER project was meant to focus on research to create sustainable markets.

The market models that have been used for the development, design, construction, sale, and financing of ZEH communities rely on traditional models for these activities, with a few exceptions. Mortgages are available that recognize the value that basically allows a homebuyer to qualify for a ZEH that is comparable in size and amenities to a non-ZEH. This is significant because the energy efficiency features and PV equipment add cost to these homes.<sup>2</sup> In addition, builders in the Building America demonstration projects have minimized this additional cost by having less mark-up on these features.

This PIER project sought to look much more broadly at the market and identify all the stakeholders and all the cash flows that are involved in the delivery of optimized homes. Areas that can lead to reduced costs have been identified in the Building America research though are not thoroughly understood. These areas include improvements to the entitlement process, streamlined PV installation methods, and more creative mortgage structures.

In the broader context, the PIER project team hoped to address all the cash flows of all the market participants. Particular emphasis was to be placed on the role of the electric utility, understanding the benefits that optimized-home communities have for the utility and the electricity supply grid, and creating relationships between the utility and other market participants that promote a sustainable market.

## **1.2. Project Objectives**

The goals of this project were to develop sustainable business models for development, design, construction, financing, and ownership of high performance homes. A major focus of the market model development process was to explore the benefits produced from these homes for the electric utility and to develop market models in which the electric utility can serve as a major driver for reducing the cost to the homeowner.

Specific objectives were as follows:

- Create home designs that are optimized for energy efficiency, onsite electricity production, and cost effectiveness and are adapted for California Climate Zones 8 through 13.
- Explore and develop near-term opportunities to reduce the cost of the optimized home designs.

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<sup>1</sup> Building America is a national energy efficiency program, [http://www1.eere.energy.gov/buildings/building\\_america/about.html](http://www1.eere.energy.gov/buildings/building_america/about.html).

<sup>2</sup> The energy bills in these homes are substantially less than in a base case home, allowing more of a homeowner's income to be freed to apply toward a higher mortgage payment.

- Develop sustainable market models that promote the development and ownership of energy-efficient, solar-powered homes.
- Work with a builder to demonstrate at least 75 homes with the recommended home designs in Southern California. Evaluate the energy performance of at least 20 percent of the demonstration homes on the customer side of the meter.
- Evaluate the entire development of the optimized homes on the utility side of the meter. Also evaluate a development of similar-sized new homes built only to Title 24 standards on the utility side of the meter.
- Quantify the electric utility benefits from the optimized homes to identify possible electric utility resources that can underwrite the long-term expansion and sustainability of this concept. Quantify the benefits to the homebuyer and to the electric utility.
- Identify the key technical, regulatory, and legal hurdles to the implementation of a utility-sponsored ZENH program.
- Evaluate three potential market models to test in a utility-sponsored Pilot Program; (1) utility owned and maintained PV connected to the customer side of the meter; (2) utility owned and maintained PV connected to the utility side of the meter; and (3) customer owned and maintained PV connected to the customer side of the meter.
- Identify all the documents and marketing strategies necessary to promote the sustainability of the utility-sponsored Pilot Program.

### **1.3. Benefits to California**

The potential impact on the state of California energy and demand use was estimated as follows. If ZENHs comprised 5 percent of all new homes:

- The cumulative impact on the electrical system statewide in 2010 could be:
  - Demand savings of 87.1 megawatts (MW).
  - Energy savings of 343,902 megawatt-hours (MWh).
- The cumulative impact on the electrical system statewide in 2015 could be:
  - Demand savings of 175.8 MW.
  - Energy savings of 694,456 MWh.

Five case studies<sup>3</sup> involving homes that were designed with additional energy efficiency features and included PV installations were researched at the beginning of this project. The research confirmed that optimized homes use less energy. Based on the electric bills from the Sacramento Municipal Utility District (SMUD), the homes at Premier Gardens by Premier Homes consumed less energy than typical Title 24 homes, and consequently had lower electricity bills. More importantly, these homes helped reduce peak demands for summer afternoon loads. The afternoon PV generation of the homes overlapped with the utility's peak load period. SMUD benefits directly by seeing reduced peak demand and the ratepayer benefits indirectly, because they ultimately pay for new utility infrastructure and that would otherwise be needed to meet the peak demand.

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<sup>3</sup> Task 2.1 unpublished report titled "Design Process Case Study for the Demonstration ZENHs." See Appendix VII.

## 1.4. Commercialization Potential

A significant net incremental cost ranging from \$9,550 to \$21,910 per house exists going from Title 24-compliant standards to a more energy-efficient home with a PV system. The incremental cost varied greatly depending on home size and California climate zone. This cost factor continues to be a financial challenge to the builders as they have no idea if the costs can be recovered at the point of sale. In researching the five case studies, the project team found that incorporating the extra features and the PV system was a financial burden at the beginning of all the projects. However, most builders successfully recovered their costs when the homes sold.

In 2007, the state began a 10-year, \$400 million program to encourage the installation of PV systems on energy-efficient new homes, both single-family and multifamily, including affordable housing. This program is known as the New Solar Homes Partnership (NSHP). Its stated goal is to achieve 400 MW of installed solar electric capacity in California by the end of 2016. The NSHP provides incentives to builders based on the projected electricity generation of the installed systems rather than on DC power ratings.<sup>4</sup> The NSHP also provides technical and marketing support for builders participating in the program. While the NSHP promotes renewable energy, it also requires energy efficiency as a prerequisite for the NSHP incentives.

California's PV incentive programs have done much to stimulate the installation of residential PV systems. According to *Renewable Energy World* magazine, U.S. demand in the PV residential market continues to be dominated primarily by California, largely due to the success of its PV rebate programs, followed by New Jersey. Together, these two states represented nearly 90 percent of all U.S. grid-tied applications in 2006.<sup>5</sup> Nevertheless, widespread market penetration of PV systems in the residential sector remains relatively small, and California, like the rest of the United States, has an increasing problem with the costs and ability to provide electrical power during peak-demand periods that occur on hot summer days.<sup>6</sup>

## 1.5. Builder-Partners

Since this PIER project began in 2005, the project team unsuccessfully worked with four builders to construct 75 homes to the ZENH program requirements. The first and original builder was Pulte Homes with a project in Orange County (Climate Zone 8). Due to change of management, Pulte Homes decided not to participate. The second builder and project was Pardee Homes in Santa Clarita (Climate Zone 9). The team started Task 2 (ZENH Design) and Task 3 (ZENH Design Guideline) using Pardee Homes' "Golden Valley" project. Though the initial stages of the project were completed, Pardee Homes decided to cancel this project due to land issues. The team then worked with Clarum Homes to build the "Two Bunch Palms" in

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4 This is also referred to as an Expected Performance-Based Incentive (EPBI) and marks a strong move in the state away from upfront capacity-based subsidies.

5 See [http://www.renewable-energy-world.com/display\\_article/305266/121/CRTIS/none/none/PV-market-update:-Demand-grows-quickly-and-supply-races-to-catch-up/](http://www.renewable-energy-world.com/display_article/305266/121/CRTIS/none/none/PV-market-update:-Demand-grows-quickly-and-supply-races-to-catch-up/)

6 The Energy Information Administration (EIA) reports a total of 688 MW of residential PV capacity in the United States in 2006. This is a modeled estimate based on manufacturer reports of PV shipments and an estimated equipment lifespan of 20 years. This information is based on phone conversation with Louise Guey-Lee of the EIA. As for California, as of 2004, solar represented only 0.3% of California's overall electricity supply. See [http://www.gosolarcalifornia.ca.gov/information/big\\_picture.html](http://www.gosolarcalifornia.ca.gov/information/big_picture.html).

Desert Hot Springs (Climate Zone 15). Although this project was not in the preferred Climate Zones 8 through 13, the Energy Commission authorized the team to proceed. Unfortunately, Clarum Home cancelled the project due to land issues with the city of Desert Hot Springs. The project team then worked with a fourth builder, Prestige Homes, to build “The Retreat” project in Corona, (Climate Zone 10). After providing many cost benefit analyses and working with the architects to optimize the solar systems on the site plan, the builder could not convince the Prestige corporate office to build to the Energy Commission’s ZENH home design standards. (See chapter 2)

Overall, these builders were simultaneously experiencing the downside of the housing market, which contributed to their decisions not to build to ZENH homes design standards. In addition, most of the builders were trying to reduce costs, which made participation in this PIER project a risky option. Other builders were considered, including Victoria Homes, Lennar Homes, William Lyon Homes, and Brookfield Homes.

In spring 2007, the project team approached a builder called K Street East LLC in Lancaster, California, in Climate Zone 14. K Street East LLC agreed to build the O Bel Sole project to a set of modified home design requirements. The Energy Commission approved the design modifications. K Street completed three model homes in fall 2007. This project ultimately was affected by the lack of home sales. Of the planned 41-home community, K Street had started construction on 14 homes by summer 2008, and none had sold. This is when the project team decided to discontinue the tasks related to circuit and end-use monitoring of occupied homes and surveying homeowners. The monitoring period had been scheduled to last for one year, and the contract was scheduled to end May 1, 2009. As of December 2008, K Street had completed 17 homes (including the three models) and sold two homes, and four more were in escrow. All were built with the recommended energy efficiency measures and functioning PV systems. The monitoring equipment and home displays that had been installed were removed. Plans in 2009 for the builder-partner were to look at downsizing the next phase of homes and making the PV systems optional.

Additional information about the builder-partners is contained in Appendix I.



## 2.0 Task 2 Zero Energy New Homes (ZENH) Design

### 2.1. Task 2<sup>7</sup> Approach

The goal of this task was to create home designs that met the program performance goals shown in Table 1. The project team initially researched other zero energy residential communities and used the results to inform the design. Concurrently, the project team planned to work with the builder-partner and the PV-partner to identify a package of energy efficiency measures and PV system selections that met the performance goals for the California climate zone where the demonstration homes would be located. The homes would incorporate the design concepts. Based on feedback from the construction process and the monitoring results of the demonstration homes, the partners would generate a final set of design concepts that would include meeting the same program performance goals for other California climate zones.

Additionally, the team developed commissioning protocols and procedures to ensure the homes would meet design and performance specifications. The team used these protocols and procedures during the demonstration phase to coordinate with the builder-partner and the building contractors to resolve any construction problems arising from the optimized home design.

ConSol researched previous projects and took the lead on the development of the design concepts. AEC and SCE performed additional analyses and design review. ConSol performed the analyses that extended the design concepts to additional climate zones and provided the commissioning guidelines.

### 2.2. Task 2 Outcomes

#### 2.2.1. *Research of Previous Projects*

Based on research from five case studies<sup>8</sup> of zero energy home communities in California, the project team identified several major benefits to developing ZEH communities:

- Federal and utility incentives/rebates help defray costs and are essential.
- Marketing and media exposure contributed to the success of the homes sales.
- Collaborative partnerships were formed with business, non-profit, and government agencies as a result of the ZEH projects.
- The ZEHs sold as competitively as conventional homes.
- The builders felt their reputation was enhanced and experienced positive exposure.

Although the ZEH builders experienced numerous benefits, several disadvantages surfaced. Upfront cost was an issue for builders, even after rebates and incentives. ZEH features should be offered as standard and not be sold as options due to the investment of time, effort, and cost. Builders, contractors, and the builders' sales staff face a steep learning curve. Local government building plan checkers and inspectors are unfamiliar with some HVAC technologies and PV system configurations, providing additional barriers to acceptance. The amount of time and

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<sup>7</sup> Task 1 included only administrative tasks: AEC is not reporting on those in this report.

<sup>8</sup> Case studies are featured in Task 2.1 unpublished report titled "Design Process Case Study for the Demonstration ZENHs." See Appendix VII.

paperwork associated with submitting for rebates and the permitting and inspections can be overwhelming for the builders.

## **2.2.2. Development of ZENH Design Concepts**

### **Program Requirement Changes**

Since the project team unsuccessfully worked with four builders during a three-year period to design and build the demonstration homes, the team proposed new performance goals that the Energy Commission accepted. These goals are summarized in Table 2.

**Table 2. Summary of program changes**

<b>Program Goals/Requirements</b>	<b>Old</b>	<b>New</b>
Energy performance to exceed 2005 Title 24	25%	35% (with 40% cooling reduction)
Annual Electric Bill Savings	70%	60%
Peak Electricity Demand Use	1 kW maximum	50% reduction from Code House to ZENH House
Number of Homes	75	41
CA Climate Zones	8-13	8-14

Source: Architectural Energy Corporation

### **Design Requirement Changes**

Changes to the design requirements were discussed in great detail with various Program Advisory Committee (PAC) members<sup>9</sup> and Commission staff. In terms of the peak day calculation, the team agreed that it should be consistent with the Database for Energy Efficient Resources (DEER)<sup>10</sup> methods used by the investor-owned utilities (IOUs). The DEER methodologies include the kW average draw from July 15 through July 17 from 2 p.m. to 5 p.m.

In addition, the electric bill analysis would be based on how each house performs annually (8760 hours), using SCE's tiered rate structure for winter and summer months. With regard to lighting, appliances, and plug loads, the team agreed to use the Building America approach, which has higher loads and is more representative than the Pacific Gas and Electric data. These changes are summarized in Table 3.

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9 Program Advisory Members included Iain Walker, Staff Scientist, Energy Performance of Buildings Group, Lawrence Berkeley National Laboratory, Jeff Jacobs, Project Manager, Centex Homes Northern California, Richard Koon, Executive Vice President, Indy Mac Bank Homebuilder Division, Dr. Hofu Wu, FAIA, Professor, Department of Architecture, Director, Environmental Design Technology Unit, California State Polytechnic University, Jesse Wolf Corsi Henson, AIA, LEED AP, Corporate Engineering Architect, KYOCERA Solar, Lew Pratsch, Zero Energy Homes Project Manager, Office of Building Technologies, DOE, Noah Horowitz, Senior Scientist, Natural Resource Defense Council, Bradley Collins, Executive Director, American Solar Energy Society.

10 Database for Energy Efficient Resources (<http://www.energy.ca.gov/deer/>): California Energy Commission and California Public Utilities Commission (CPUC) sponsored database designed to provide well-documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) all with one data source.

**Table 3. Summary of design changes**

<b>Design Requirement</b>	<b>Old</b>	<b>New</b>
Peak Day Calculation	TMY2 Data	DEER Approach
Electric Bill Analysis	Use Average Cents/kWh	Use Schedule D Tier Rate per SCE
Lighting Load	PG&E Data	Building America assumptions
Appliances / Plug Load	PG&E Data	Building America assumptions

Source: Architectural Energy Corporation

### **ZENH Design Process**

In spring 2007, the project team approached a builder called K Street East LLC, who agreed to build the O Bel Sole project in Lancaster, California, located in Climate Zone 14, which would meet the revised ZENH performance requirements. Forty-one demonstration homes were planned in the O Bel Sole community with three plan types. Each plan type (A, B, and C) had three different elevations with varying rooflines and facades. One elevation from each plan was selected to evaluate for optimized features. A specific elevation from each plan type was chosen using an orientation that had the highest energy load. The rationale was if the worst-case orientation achieved the program performance goals, then all other orientations would perform better.

The initial energy efficiency measures that the project team recommended to K Street East LLC included increasing the wall insulation from R-19 to R-21, upgrading window products from dual pane to triple pane, and upgrading the HVAC system from 92 percent AFUE (Annual Fuel Utilization Efficiency) and 14 SEER (Seasonal Energy Efficiency Ratio) to 95 percent AFUE and 16 SEER. A PV system was initially sized based on available roof area on the south and west sides and projected cost impacts.

The subdivision layout of the O Bel Sole demonstration project was evaluated for improved solar orientation and performance. Each home's architectural designs were evaluated for possible improvements in solar performance for both summer and winter. As a result, a majority of the PV systems were designed to face west for optimal generation to offset peak demand. Design analyses were provided to the builder-partner, including analyses of energy and demand impacts, cost and availability of components, cost-benefits, construction impacts, and risk and reliability.

The design process included modeling for code compliance and energy efficiency using Micropas<sup>®</sup> software.<sup>11</sup> ConSol prepared hourly loads and performance estimates using Micropas, and AEC did the same using DOE 2.<sup>12</sup> Based on the simulations, performance

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11 Micropas is one of two certified software packages used in California for residential energy code compliance and is certified for federal, state, and utility rebate programs. Micropas is a product of Enercomp, Inc.

12 DOE 2 software was developed by James J. Hirsch & Associates (JJH) in collaboration with Lawrence Berkeley National Laboratory (LBNL), [www.doe2.com](http://www.doe2.com).

predictions for annual energy consumption, cost by end uses, and summer on-peak demand were projected. The kWh and energy bill (electric and gas) estimates were consistent using the two different software programs. SCE also confirmed the consistency with different DOE 2 software, EQuest.<sup>13</sup>

The team analyzed the results for building code compliance under the Title 24 2005 Residential Code standards and qualification under the NSHP Program. NSHP offered two levels of rebates for PV: one for homes exceeding Title 24 by 15 percent and one for homes exceeding Title 24 by 35 percent. For O Bel Sole, the total compliance budget from the Micropas simulation (space heating, space cooling, and water heating) for the new design must be at least 35 percent better with 40 percent cooling reduction compared to a Title-24 house. The annual Micropas energy use combined with the energy usage of the appliances, appliance/plug loads, and lighting also must result in an annual electric bill savings of at least 60 percent compared to the Title 24 house. ENERGY STAR® appliances such as the clothes washer and refrigerator were assumed to be at least 30 percent more energy-efficient than typical appliances. The annual miscellaneous electric and lighting loads were based on the Building America benchmark requirements.<sup>14</sup>

One of O Bel Sole's performance goals was that the peak demand be reduced by 50 percent from the Title 24 house. The project team calculated the peak hourly consumption for one of the demonstration homes using the DEER methods by averaging the kW loads from 2 to 5 p.m. from July 15 through 17. The team obtained the PV system sizes and hourly generation output from the PV Watts calculator software.<sup>15</sup> The three different PV systems for this project would be installed on the west orientation at 23-degree tilt (5:12 roof pitch). The team's analysts averaged PV output from 2 to 5 p.m. for July 15<sup>th</sup> through 17<sup>th</sup> to obtain the peak PV output. Figure 1 shows the analysis results for O Bel Sole's Plan A.

The 3.0 kW reduction in the average peak cooling load represents a 47 percent reduction in the optimized home design cooling load compared to the base Title 24 design. The total net reduction in cooling and non-cooling peak load including PV production is 4.6 kW. About a third (1.49 kW) of the reduction can be attributed to PV generation.

### ***Design Concepts for Demonstration Homes***

Table 4 summarizes the results of the analysis comparing the base Title 24 house with the team's recommendations for optimized house design, including features, costs, and energy savings.

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<sup>13</sup> <http://www.doe2.com/equest/>

<sup>14</sup> [www.eere.energy.gov/buildings/building\\_america/docs/benchmark\\_2005.doc](http://www.eere.energy.gov/buildings/building_america/docs/benchmark_2005.doc)

<sup>15</sup> DOE software developed by National Renewable Energy Laboratory, <http://www.nrel.gov/rredc/pvwatts/>

**Figure 1. Peak load calculations for Plan A**

Base (DEER)		O Bel Sole Model A (DEER)		PV Watts (2.3 kW DC)
July 15th	kW Draw	July 15th	kW Draw	kWh Generation
2-3 PM	5.488	2-3 PM	1.614	1.576
3-4 PM	6.845	3-4 PM	3.779	1.534
4-5 PM	7.567	4-5 PM	4.179	1.543
July 16th		July 16th		
2-3 PM	5.785	2-3 PM	3.251	1.574
3-4 PM	6.418	3-4 PM	3.587	1.518
4-5 PM	6.927	4-5 PM	3.885	1.355
July 17th		July 17th		
2-3 PM	5.82	2-3 PM	3.269	1.542
3-4 PM	6.388	3-4 PM	3.571	1.449
4-5 PM	6.733	4-5 PM	3.789	1.355
Average =	<b>6.44</b>	Average =	<b>3.44</b>	<b>1.49</b>
Non-cooling =	0.963	Non-cooling =	0.860	
PV Output =	0.00	Ave PV Output =	1.49	
<b>Total Load =</b>	<b>7.40</b>	<b>Total Load =</b>	<b>2.80</b>	

Source: Architectural Energy Corporation

**Table 4. Summary of analyses**

Feature	Base T-24 House	Optimized House Design
Attic Insulation	R-38 / R-19 at Furnace platform	R-49 / R-19 at Furnace platform
Wall Insulation	R-13 (2x6)	R-21 (2x6)
Floor Insulation (Incl. above garage and cantilevered to exterior)	R-19	R-30
Low Air Infiltration – Tested	No	Yes
Radiant Barrier	No	Yes
Quality Installation of Insulation – Verified	No	Yes
Glazing (U-factor and SHGC)	0.45 U-factor 0.45 SHGC	Sliding (U=0.20, SHGC = 0.22), Single-hung (U=0.20, SHGC=0.22), Fixed (U=0.16, SHGC = 0.24), Patio Door (U=0.33, SHGC =0.34), French Door (U=0.40, SHGC = 0.40)
HVAC Efficiencies / Tonnage	80% AFUE 13.0 SEER	95% AFUE 16.0 TXV SEER (up to 1 ton reduction in HVAC system)
Duct Insulation / Location	R-4.2 @ Attic	R-6 @ Buried in Insulation
Tight Duct and ACCA Manual D	Yes	Yes
Water Heater	50 Gal EF = 0.60	2 Tankless EF = 0.82 w/ R-4 pipe insulation on all major trunks
Lighting	2005 Package	2005 Fluorescent Lighting Package

Feature	Base T-24 House	Optimized House Design
Dryer	Electric	Gas
PV System Size	None	2.3 kW DC (Plan A) 2.6 kW DC (Plan B) 2.8 kW DC (Plan C)
Annual Energy Savings over T-24*	N/A	45.3% (Plan A) 46.6% (Plan B) 46.0% (Plan C)
Annual Electric Savings	N/A	61% (Plan A) 64% (Plan B) 64% (Plan C)
Total Peak Energy Demand/Demand Reduction	7.40 kW (Plan A) 8.98 kW (Plan B) 9.24 kW (Plan C)	2.8 kW (Plan A)/62% Demand Reduction 3.35 kW (Plan B)/62% Demand Reduction 3.0 kW (Plan C)/67% Demand Reduction
Total Estimated Increase in Cost	N/A	\$12,610 (Plan A) \$13,024 (Plan B) \$13,720 (Plan C)

\* The worst-case orientation, facing east, represents the highest load; all other orientations should perform better.

Source: Architectural Energy Corporation

Recommended PV system sizes for the three plan types are 2.3 kW DC (Plan A), 2.6 kW DC (Plan B), and 2.8 kW DC (Plan C). The largest plan has the biggest PV system. Using the combined components, all of the demonstration homes would achieve the revised program goals and design requirements; the team estimated that the peak load for all plans would achieve the 50 percent reduction.

The team estimated the total net incremental cost to be \$12,610 (Plan A), \$13,024 (Plan B), and \$13,720 (Plan C), which included available rebates and tax credits. The cost of the PV systems to the builder included the NSHP rebates (\$2.60/watt). Other rebates to the builder included \$2,000 from the Internal Revenue Service (for being 50 percent above 2004 International Energy Conservation Code [IECC]), \$200 per tankless water heater (\$400 for two) from the Southern California Gas Company, and \$2,000 from SCE for qualifying under the California ENERGY STAR New Homes Program. An additional one-time \$2,000 federal energy tax credit to the homebuyer for the PV system was available.

All plans demonstrated a positive cash flow beginning the first year when the incremental cost and the electric bill savings were compared. The incremental cost for Plan A was \$12,610 or \$83.90/month for a 30-year mortgage based on 7 percent interest. The electric bill savings was \$142.25 per month, resulting in a net savings of \$58.35/month.

The team projected the annual cash flow savings for Plans B and C to be \$84.40/month and \$88.05/month and analyzed the energy bills based on SCE Schedule D<sup>16</sup> tier rate structure. Table 5 shows the estimated cash flow for the three house plans.

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16 Rates schedules from SCE available at <http://www.sce.com/CustomerService/QuickAnswers/Rates/>

**Table 5. First year monthly cash flow**

<b>First Year Monthly Cash Flow</b>			
<b>O Bel Sole</b>	<b>Plan A</b>	<b>Plan B</b>	<b>Plan C</b>
Code Home Monthly Energy Bill =	\$265.44	\$303.05	\$316.70
ZENH Home Monthly Energy Bill =	\$123.20	\$132.00	\$137.37
Total Monthly Energy Bill Savings =	\$142.25	\$171.05	\$179.33
Amount Borrowed (Total Incre. Cost) =	\$12,610	\$13,024	\$13,720
Interest =	7.00%	7.00%	7.00%
Monthly Payment on Incre Cost =	\$83.90	\$86.65	\$91.28
<b>Monthly Cash Flow =</b>	<b>\$58.35</b>	<b>\$84.40</b>	<b>\$88.05</b>

Source: Architectural Energy Corporation

The team found that the incremental cost estimates fluctuated during the course of the project. Changes in material and labor costs, builder and contractor mark-ups, interest rates, and incentives continuously influenced cash flows.

### **2.2.3. Design Concepts Expanded to Other Climate Zones**

The project team analyzed three different size house plans in six different California climate zones. Homes were 1,697, 2,197, and 2,697 square feet. The three home plans incorporated varying degrees of energy-efficient features and PV systems that ranged from 1.6 to 3.5 kW DC. The energy-efficient features and PV systems were similar to those recommended to the builder-partner for the demonstration homes, and the project team used the same simulation tools and assumptions. The optimized designs had to meet or exceed the original project goals of 25 percent better than 2005 Title 24 Energy Efficiency Standards, annual electric bill reduction by 70 percent, and no more than one kW demand during summer peaks.

Different utilities serve each climate zone and have different system peak days. The team evaluated the utilities' system peak days using the worst case system peak day for each climate zone. The optimized design features for these "worst" cases should apply for all utilities or municipalities within these climate zones. The analyses used system peak day information from two utilities, SCE and PG&E, and the "worst" cases were August 11<sup>th</sup> at 4 p.m. for SCE (Climate Zones 8, 9, and 10) and July 14<sup>th</sup> at 5 p.m. for PG&E (Climate Zones 11, 12, and 13).

The optimized design features for the three house plans varied based on the climate zones and house sizes. For example, smaller homes in mild Climate Zones 8, 9, and 10 can achieve lower energy use more easily and have fewer or less significant energy measures than larger homes in Climate Zones 11 or 12. Achieving low energy and demand use in Climate Zone 13 is difficult, especially the one kW peak demand requirement, and requires substantial energy features as well as larger PV systems resulting in higher incremental cost. The research team found that the incremental cost of the optimized designs compared to base Title 24 designs for 1697 to 2697 sq. ft. homes in Climate Zones 8 through 13 varies from \$9,550 to \$21,910. Table 6 illustrates the results of the three house plans that incorporated varying degrees of energy efficiency and PV to reach the project goals for the various climate zones.

**Table 6. Summary data for optimized house designs by size for Climate Zones 8-13**

Home Design Data	Climate Zone					
	8	9	10	11	12	13
<b>For a 1697 Sq. Ft. House Size</b>						
Incremental Cost from Title 24 to ZENH to the Builder*	\$9,550	\$10,695	\$11,545	\$12,690	\$12,690	\$12,620
Photovoltaic Buyer Rebates (Includes \$2000 Federal Tax Credit)	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000
Percent above 2005 Title 24	29%	31%	34%	25%	25%	46%
Annual Electric Bill Reduction	70%	72%	70%	73%	73%	79%
Peak Draw (kW)	0.2	0.4	0.7	0.1	0.1	1.0
<b>For a 2197 Sq. Ft. House Size</b>						
Incremental Cost from Title 24 to ZENH to the Builder*	\$11,105	\$12,250	\$13,300	\$13,134	\$13,134	\$21,692
Photovoltaic Buyer Rebates (Includes \$2000 Federal Tax Credit)	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000
Percent above 2005 Title 24	30%	32%	39%	32%	32%	47%
Annual Electric Bill Reduction	72%	73%	72%	72%	72%	87%
Peak Draw (kW)	0.5	0.7	0.9	0.3	0.3	1.0
<b>For a 2697 Sq. Ft. House Size</b>						
Incremental Cost from Title 24 to ZENH to the Builder*	\$13,152	\$14,297	\$11,150	\$13,830	\$13,830	\$21,910
Photovoltaic Buyer Rebates (Includes \$2000 Federal Tax Credit)	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000
Percent above 2005 Title 24	31%	32%	41%	33%	33%	40%
Annual Electric Bill Reduction	74%	74%	71%	79%	79%	81%
Peak Draw (kW)	0.6	0.8	1.0	0.3	0.3	1.0
*{						

\*Excludes \$2,000 Federal Tax Credit for meeting 50% above IECC. Actual plans need to be analyzed for each home to determine if the 50% above IECC is achieved.

Source: Architectural Energy Corporation

#### **2.2.4. Commissioning Protocols and Procedures**

Commissioning is a process that assures a homeowner that certain equipment included in the home is correctly installed, the final product is correctly assembled, and the house and equipment will perform as intended. Commissioning is done after construction is complete and before occupancy. Commissioning can include other activities such as auditing, rating, super-commissioning (activities to optimize performance beyond design intent), or retro-commissioning (to adjust performance of existing facilities). As such, it represents an expansion of processes currently performed by home energy raters, home inspectors, PV installers, auditors, weatherization contractors, and others.

The project team produced a set of commissioning guidelines for homes, relying heavily on information in a Lawrence Berkeley National Laboratory report.<sup>17</sup> The project team intended to use these guidelines during the demonstration phase of this project. However, after the three model homes were constructed, further construction was significantly delayed.

Key areas of home construction that need to be reviewed and commissioned are:

- The building envelope is important to the performance of a house because envelope loads dominate the house heat transfer mechanisms. In new houses, installation failures, especially in insulation and air sealing, can cause immediate energy consumption and comfort problems.
- Duct leakage, duct insulation compression, and other poor installation practices can reduce duct efficiency from even a moderate level of design performance. Poor installation and operation of the air distribution systems waste energy and can cause comfort problems, structural moisture problems, and poor indoor environmental quality.
- Even in new houses, cooling systems rarely perform as intended. In particular, refrigerant charge levels and airflow across coils often do not meet manufacturers specifications used in the system design. As a result, the capacity and efficiency of the equipment can be substantially degraded.
- Fueled appliances must vent as intended. Poor installation of either the combustion equipment or air moving equipment can reduce efficiency and lead to backdrafting and combustion gas spillage or other hazards. Such events, along with insufficient ventilation for unvented combustion appliances, can directly affect the indoor environment and cause health or comfort problems.<sup>18</sup>
- Reducing thermal bypasses are important as they can lead to comfort and warranty issues as well as higher utility bills. ENERGY STAR has a 16-point list of building details where thermal bypass, movement of heat around or through insulation, frequently occurs due to missing air barriers or gaps between the air barrier and insulation.

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17 Wray, C.P., I.S. Walker, and M.H. Sherman. 2003. *Guidelines for Residential Commissioning*. Lawrence Berkeley National Laboratory report LBNL-48767.

18 *Ibid.*

## **2.3. Task 2 Conclusions and Recommendations**

### **2.3.1. Conclusions**

#### ***Research of Previous ZENH Communities***

This research provided several conclusions:

- Being innovative in building ZENH can result in extensive exposure and media attention, translating into free advertisement and marketing for builders.
- Overall, when evaluating comparable lifestyles and behaviors, a ZENH will use less energy than a typical Title 24 home.
- ZENH owners are very pleased that 1) they will be saving money due to the lower energy bills and 2) they are somewhat insured against energy price volatility. It is important to note that lifestyles and behaviors of homeowners affect energy bills and that some ZENHs may use more energy than typical Title 24 homes. For example, the ZENH owner may decide to add a swimming pool, spa, or multiple appliances to the home. In the Morrison Homes Lakeside project, one of the ZENHs had consistently low energy bills for a few months and then the bills suddenly tripled. A spa, more televisions, and a swimming pool were the culprits.
- Builders do not typically install PV systems on the front side of homes because PV is viewed as obtrusive and unattractive.

The full report of this research is referenced in Appendix VII.

#### ***Development of ZENH Design Concepts***

The development of design concepts yielded several conclusions:

- All the homes in the O Bel Sole project by K Street East LLC were projected to achieve the revised project goals and design requirements.
- All three plans also were projected to achieve positive cash flow, when comparing the energy bill savings of a code only home with they project optimized home to the incremental 30-year mortgage cost of the optimized features, beginning in year one.
- The majority of the PV systems were planned to be installed on the west orientation to capture the most sunlight to maximize generation in offsetting SCE's system peak period.
- Reaching a summer peak demand of only one kW per housing unit is extremely challenging for relatively large homes in very hot climates.

The full report of this research is referenced in Appendix VII.

#### ***Design Concepts Expanded to Other Climate Zones***

Expanding the design concepts to other climate zones provided the following conclusions:

- Home size and climate greatly affect energy use. Smaller homes in mild climates can easily achieve near zero energy use annually and will have lower first costs than larger homes in harsher climate zones. Larger homes in harsher climate zones typically have highest incremental costs and the most significant energy efficiency measures combined with the largest PV system to achieve near zero energy use.

- Human behavior still plays a significant role in reducing or increasing energy use.

The full report of this research is referenced in Appendix VII.

### ***Commissioning Protocols and Procedures***

Developing this information yielded the following conclusions:

- As home developers and builders increase the energy efficiency of their homes, they must utilize increasingly sophisticated components that are more efficient and reliable, ultimately providing greater savings to the consumer.
- The commissioning process ensures that new homes meet design and performance specifications for these newer technologies. Commissioning project requirements are included in the construction documents and are designed to aid contractors during building and in post-construction verification.

The full report of this research is referenced in Appendix VII.

### ***2.3.2. Recommendations***

- Research should continue for house designs to achieve net zero energy use.
- Commissioning protocols should be fine-tuned and commissioning promoted as part of the strategy for reaching net zero energy use.
- Federal, state and local jurisdictions should continue rebates and incentives for builders and homeowners to minimize the first cost of efficiency-optimized homes with PV systems.
- Marketing teams should identify and attempt to quantify benefits gained from media coverage and mortgage advantages from significantly lower energy bills.
- Local government participants need to be knowledgeable about optimized energy features and PV systems. Some of the energy-efficiency features (e.g., alternative wall construction, buried ducts, evaporative cooling technologies) could require significant discussions with the local building department, resulting in project delays. Builders and the NSHP program must work proactively with building departments to facilitate understanding of the features and minimize delays and, if possible, make these projects highly visible within the local government.
- One of the original goals for the PIER ZENH Program was to achieve one kW peak demand in each home. It is important to note that the ease with which the one kW goal can be met is dependent on the size of the home. The one kW goal will be harder to achieve for larger homes and those located in harsher climate zones. Perhaps the program goal should be changed to only be to show a first-year positive cash flow comparing the energy bills versus the mortgage payment even though the home does not meet the one kW goal.
- Builders and contractors should provide documentation and verification of the performance of all energy measures and systems.



## 3.0 Task 3 Innovative ZENH Business Models

### 3.1. Task 3 Approach

The goal of this task was to develop sustainable business models for energy utility companies' zero energy home programs. Task 3 activities included the following:

- The project team developed a business model that could be used during the demonstration phase. The model was based on the homeowner owning and maintaining the energy efficiency measures and the PV system.
- The team helped the builder-partner pursue incentives from the Energy Commission through the New Solar Homes Partnership<sup>19</sup> and from SCE through its California ENERGY STAR New Homes Program.<sup>20</sup> All of the associated cash flows were analyzed.
- The effectiveness of the model during the construction, sale, and occupation of the demonstration homes would be monitored. The project team would work with the builder-partner sales staff to understand the factors involved in the buying decision. Homebuyers would be surveyed initially about their decisions, and again after living in the demonstration homes for a period of time.
- Consumer Powerline was tasked with developing the business models, and AEC was responsible for the homebuyer surveys. Consol and SCE provided input into the models.

### 3.2. Task 3 Outcomes

#### 3.2.1. *Financial Analysis*

The project team prepared a financial analysis illustrating rate comparisons between SCE's Time of Use (TOU) and Domestic (D) tariffs. The team presented the analysis to the builder-partner sales team as part of the training activities. A summary is shown in Appendix II.

The analysis differed from the savings estimated in Micropas because the financial analysis calculated energy savings using the tiered SCE rate tariffs. The initial estimates using Micropas used a basic flat rate of 13 cents per kWh.

#### 3.2.2. *Demonstration Business Model*

It is important to understand how different business models may help accelerate and sustain a residential PV market and help California's NSHP reach its targeted goal of 400 MW of installed solar electric capacity in new homes by 2016. O Bel Sole used the prevalent model for PV deployment: The homeowner owns the PV system. This model is customer-driven, where individual customers must finance, purchase, and maintain PV systems. A summary table of the model attributes as applied to this PIER demonstration project follows (Table 7). The project team began the initial evaluation of this business model but could not complete it due to the lack of home sales during the project.

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<sup>19</sup> <http://www.gosolarcalifornia.org/ns hp/index.html>

<sup>20</sup> <http://www.sce.com/b-rs/bb/cali-new-homes/california-new-homes-program.htm>

**Table 7. O Bel Sole business model: Homeowners own PV**

<b>Market Model Goals</b>	Residential PV deployment through homeowner financing, ownership, and maintenance of PV system <sup>21</sup>	
<b>Economic Model</b>	Not competitive except with incentives (i.e., market “buy-downs) to offset higher up-front costs for energy efficiency measures and PV installation. Incentives are typically designed to support the market until new technology matures to a lower-cost/mass production stage or until there is more cost parity between fossil-fuel based and renewable energy supplies. Specific incentives were detailed in the Task 2 section of this report.	
<b>Target Market</b>	Early adopters or “green consumers” <sup>22</sup>	
<b>Primary Stakeholders</b>	Builder/Developer (K Street East, LLC) Homeowners Utility (SCE) Product Suppliers (SunPower) Local Municipality (Lancaster) State (Commission and California citizens)	
<b>Benefit/Risk Assessment</b>	<b>Benefit</b>	<b>Risk</b>
<b>Builder-Developer</b>	Value creation and market differentiation	Adoption and integration of new technology Lack of accessible/accurate cost/benefit information Higher costs of homes in a competitive marketplace Sales staff may not be sufficiently informed to communicate value Susceptibility of builder to market fluctuations Customer education costs Esthetic preferences of customers
<b>Homeowner</b>	Lower operating costs and utility rate volatility hedge Preferential mortgages for PV-	Adoption and maintenance of new technology Incentives may not significantly reduce the payback period for PV

21 Navigant Consulting notes that the market penetration using this model is less than 1% of peak demand. Reference Solar Power 2007 Workshop presentation at [http://www.navigantconsulting.com/A559B1/navigantnew.nsf/vGNCNTByDocKey/PPA0C5D898169/\\$FILE/SolarPower2007workshop.ppt](http://www.navigantconsulting.com/A559B1/navigantnew.nsf/vGNCNTByDocKey/PPA0C5D898169/$FILE/SolarPower2007workshop.ppt).

22 The role of early adopters or “green consumers” in driving the market and in embracing new technologies is well documented. According to a study prepared for the Commission, however, “the greatest challenge for promoting energy efficiency in new homes is in the market for first-time home buyers looking inland for the largest, most comfortable homes that they can afford. Information and resources to invest in energy-efficient options are least available to this group of homebuyers.” See “Making a Tough Sell: Options for Promoting Energy Efficiency in New California Homes” at [http://www.rand.org/pubs/working\\_papers/2005/RAND\\_WR164.pdf](http://www.rand.org/pubs/working_papers/2005/RAND_WR164.pdf).

	equipped homes	Lack of value by the appraisal community, impacting resale Increased mortgage payment (unless offset by production) Load matching of customer-owned systems may provide more value to utility than to homeowner Ongoing maintenance cost from end-user to end-user System reliability
<b>Utility</b>	No capital cost or responsibility for utility for PV system No monitoring cost for utility Capital infrastructure cost deferment Peak load hedging	PV power production does not match utility load profile System may not perform as expected
<b>Product Suppliers</b>	Deployment of new technology	System may not perform as expected
<b>State/Public</b>	Reduced carbon emissions Diversified energy portfolio	Lack of qualified professional installers and knowledgeable inspectors Potential free ridership <sup>23</sup> issues Inability to meet targeted goals because of uncertainty for primary stakeholders

Source: Architectural Energy Corporation

### 3.2.3. *Utility Model*

Another task was to study and understand the potential for two direct utility PV deployment models: where the PV system is owned and maintained by the utility, and connected to the customer side of the meter, and where the PV system is owned and maintained by the utility but connected to the utility side of the meter.

Support has been growing for direct utility PV deployment to help California shift to clean renewable energy and accelerate PV industry growth and penetration into the residential market.<sup>24</sup> While still at a conceptual stage with little to no market implementation at the time of this report, the model assumes a range of benefits unique to strategic utility investments in PV. Many of the risks and benefits transfer from homeowners and homebuilders to the utility.

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23 Free ridership is the concept that an individual would install an energy efficiency measure without incentives because of the return on investment, but is able to receive a financial incentive or rebate anyway

24 See *Integrated Utility-Driven Solar PV: Key to Keeping Clean Distributed Resources in the Race to Meet Carbon-Reduction Goals*, Cliburn and Robertson, ACEEE Summer Study 2006, at <http://www.electricsun.org/images/integrated-utility-driv.pdf>.

### **3.2.4. Alternative Models**

A number of alternative models exist for PV deployment, both nationally and internationally, that may benefit the state as it considers alternative means of rapidly accelerating solar energy utilization.

#### ***Utility Facilitation of PV Deployment***

In 1993, SMUD launched its PV Pioneer I program and became the first municipality to engage in bulk purchasing to drive down the price of PV. SMUD's Pioneer I program required participating customers to pay an additional \$4 per month to have SMUD install a 2 to 4 kW solar array on their rooftops. This additional fee covered only a portion of SMUD's cost of the PV systems. SMUD spread the remaining costs across its entire customer base. The energy from these PV Pioneers went directly into SMUD's grid. As follow-up, SMUD initiated the PV Pioneer II program where SMUD customers purchased a PV system for their home from SMUD. SMUD contracted with local installation contractors to install SMUD supplied equipment. SMUD offered the systems at deep discounts and allowed net metering.

According to Jim Barnett, Principal Architect at SMUD,<sup>25</sup> the PV Pioneer II program differed from the first in that it required an interested customer to contract directly with SMUD. The utility, as the primary responsible party, took on significant liability and warranty exposure. SMUD now has an approximate \$200,000 annual budget for maintenance issues stemming from the PV Pioneer I and II programs, including, but not limited to the following:

- Some solar companies from which SMUD purchased PV systems went out of business or moved.
- Original inverters were non-replaceable low-voltage inverters. Upgrading to high-voltage inverters involved a considerable expense.

Around 2004, the PV Pioneer program was again modified. The residential retrofit program became contractor-driven. PV installers contract with SMUD customers, handle the paperwork, and receive the incentives.

In 2007, SMUD added a program for new houses, the SolarSmart™ New Home Program, which continues today. It requires that the builder/developer contract directly with a PV installer. SMUD pays the incentive to the builder. SMUD offered an initial incentive of \$3.00 per watt, based on system performance.

In addition to SMUD's core PV programs for commercial and residential markets, the utility launched its Solar Shares Program, the first of its kind in the United States. SMUD works with third-party solar developer on one-megawatt-increment PV farms. The developers can take advantage of federal tax incentives to reduce installation costs. The developers then build, own, and operate the solar farm, entering into 20-year fixed price contracts to sell all of the power to SMUD. Electric customers purchase shares from SMUD, and the purchase shows up as a reduction of kilowatt-hour (kWh) usage on their utility bills.

SMUD expects the Solar Shares Program to broaden the market for solar by providing a choice to residential customers who cannot or would not participate in current programs, due to site problems, installation issues, upfront costs, or home rental rather than ownership. SMUD also

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25 Per phone conversation with Jim Barnett, (916) 732-6762 or [jbarnet@smud.org](mailto:jbarnet@smud.org), fall 2007.

sees the program as “solar for everyone” as it increases customer equity by making PV affordable for most customer income levels.

### ***Innovative City PV Programs: Berkeley FIRST Solar Financing Program***

Berkeley FIRST is a solar financing program offered by the city of Berkeley.<sup>26</sup> It provides an opportunity for property owners to borrow money from the city’s Sustainable Energy Financing District to install PV systems. The program allows the cost to be repaid over 20 years through an annual special tax on the owner’s property tax bill. The program is intended to solve many of the financial hurdles facing property owners who want to install PV systems. The advantages of the program include the following:

- Relatively little upfront cost to the property owner is required.
- The cost is spread over 20 years.
- The financing costs are comparable to a traditional equity line or mortgage.
- The tax obligation stays with the property. If the property is transferred or sold, the new owners will pay the remaining tax obligation.

In 2008, the California State Legislature passed AB 811 (Lloyd Levine, Chapter 159, Statutes of 2008), facilitating the ability of local jurisdictions to offer this financing through property tax bills.

### ***Innovative State PV Programs: Washington State Passes Renewable Energy Legislation***

In 2005, two significant bills passed through the Washington State legislature – SB 5101 and SB 5111. SB 5101 established a renewable energy “feed-in” production incentive funded by utility tax credits, the first such approach by a state. Homes and businesses with PV and/or wind power systems would earn a credit of 15 cents per kWh of electricity generated by those systems up to \$2,000 annually, roughly tailored to the yearly market output of a typical 3.5 kW system.

In addition to the feed-in credit, SB 5101 combined economic multipliers to increase the system owner’s credit if the system’s components are manufactured in Washington. This can raise the 15 cent per kWh credit up to as much as 54 cents, and this rate would be available for a fixed 10-year period beginning July 1, 2005.

SB 5111 provided tax breaks for renewable energy businesses that resided in the state of Washington or choose to relocate there. The bill also offered higher tax breaks to companies that located themselves in economically depressed areas.<sup>27</sup>

Mike Nelson of the Northwest Solar Center reported that there was a significant legislative hurdle to overcome the first year following the passage of SB 5101 and SB 5111.<sup>28</sup> According to

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26 See <http://www.cityofberkeley.info/ContentDisplay.aspx?id=26580>.

27 For more in formation on SB 5111, see <http://www.leg.wa.gov/pub/billinfo/2005-06/Pdf/Bills/Session%20Law%202005/5111-S2.SL.pdf>.

28 Per phone conversation with Mike Nelson, Northwest Solar Center, (206) 396-8446, or [mike.nelson@northwestsolarcenter.org](mailto:mike.nelson@northwestsolarcenter.org), fall 2007.

Mr. Nelson, one of the members of the legislature wanted 80 percent agreement amongst 90 percent of the 63 utilities in the state on interconnection standards. The project team was unable to verify if the 90 percent goal. From 2006 to the time of this writing, 460 systems had been installed, and the owners received the credit of 15 cents per kWh.

### ***International Models: PV Deployment in Germany***

According to the European Photovoltaic Industry Association (EPIA), “feed-in tariffs” have proven to be the most effective market support mechanism for renewable energy, including PV.<sup>29</sup> In this feed-in tariff scenario, producers of solar electricity have the right to feed solar electricity into the public grid. Producers of solar electricity receive a premium tariff per generated kWh, reflecting the benefits of solar electricity as compared to electricity generated from fossil fuels or nuclear power. This premium is available over a fixed period of time.

Important co-measures to feed-in tariffs include simple and quick administrative procedures and guaranteed grid access by simplification and harmonization of grid connection rules across Europe. Large increases in the number of annual PV installations in Germany resulted from the feed-in tariff law. Not only has Germany created a strong solar electricity market, but it also supports a flourishing PV industry.<sup>30</sup>

### ***DOE-Funded Renewable System Interconnection Study***

In researching business models, the project team found reports by Navigant Consulting<sup>31</sup> as part of the DOE-funded Renewable System Interconnection Study, which provided in-depth analyses of various economic models for PV deployment. In particular, Navigant makes the point that utilities have core competencies and attributes that factor easily into PV business models. Most utilities are asset-intensive, have substantial maintenance programs, invest in large long-term capital programs, communicate with diverse groups of customers, mount campaigns to raise public awareness, and are knowledgeable about maximizing the electrical grid. It makes sense that utilities could add PV options as part of broader energy service packages to customers and customize the business model by customer class (e.g. commercial, industrial, residential). One scenario suggested by Navigant included utility ownership of the PV, installed at a customer site, and claimed in part as a rate-based asset. Another scenario has the utility offering PV as part of bundled energy services including flat-rate pricing, demand response, energy management, and backup power. The future role of utilities in PV business models revolves around two key issues: asset ownership and packaging of services.

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29 See <http://www.epia.org/index.php?id=136>.

30 See power point presentation by Isofoton, @ [http://www2.epia.org/04events/docs/Paris\\_Bellido\\_GridConnectedSystems.pdf](http://www2.epia.org/04events/docs/Paris_Bellido_GridConnectedSystems.pdf). Isofoton is a solar technology manufacturer located in Malaga, Spain, and the largest manufacturer of PV cells in Europe. Isofoton argues that since the German PV program has proven so successful, its principles should be used as the base for a common European PV law, thus giving the final push in the promotion and development of the European PV industry, while becoming world leaders.

31 Reports published October 2007; part of DOE-funded Renewable System Interconnection Study ([http://www1.eere.energy.gov/solar/solar\\_america/rsi.html](http://www1.eere.energy.gov/solar/solar_america/rsi.html)).

### ***Tax Treatment of Incentive Programs***

Lawrence Berkeley National Laboratory has studied and published case studies focused on property tax financing of PV systems, such as the Berkeley FIRST Program, and the implication of the federal residential investment tax credit on local, state, and utility incentive programs.<sup>32</sup> The case studies illustrate that business models, incentive programs, and federal tax credits for residential programs are in flux. Continued changes in federal tax policies will facilitate the need for local, state, and utility review of their residential PV programs. Homeowners are encouraged to seek assistance to help determine the appropriate tax treatment of incentives and rebates.

#### ***3.2.5. Monitor Effectiveness of Model***

The second part of Task 3, which involved monitoring the effectiveness of the business model during the construction, sale, and occupation of the demonstration homes, was not completed due to the lack of sales and occupied homes. AEC compiled a pre-occupancy survey for homeowners but did not use it. It is shown in Appendix III.

### **3.3. Task 3 Conclusions and Recommendations**

#### ***3.3.1. Conclusions***

While the current homeowner-ownership model incorporated in the NSHP may provide one avenue for deployment, it is rife with risks for homeowners and homebuilders as shown in Table 7. It becomes increasingly clear that more than one business model may be required to achieve rapid PV deployment in California.

In retrospect, the O Bel Sole demonstration project was not the most ideal of solar home projects. Specific lessons learned include the following:

- Early design integration is crucial. The project team was unable to impact home design and building specifications for greater efficiencies to get closer to true zero energy homes due to the late entry of the builder-partner and its architect in the project, coupled with their relative inexperience in “green” construction practices and ethics.
- Comprehensive understanding of stakeholder benefits is needed. Building energy-efficient solar homes is a very complex process, requiring a diverse set of stakeholders to set common goals and maintain the vision from design through sale of the home. The benefits, financial and otherwise, are widely distributed among the stakeholders at different points in time in the technology adoption process. In the single-family homes at O Bel Sole, for instance, using a more westerly oriented PV array may provide better load matching for a utility, but the overall electricity production for the homeowner will be lower than a south-facing array. Hence, under residential rate and incentive structures, the westerly orientation provides less financial benefit in general to the homeowner. As a result, in evaluating business models for PV on homes, it is crucial to thoroughly understand the stakeholders, their interests, and the opportunities for capturing value.
- Full risk assessment is needed. The homeowner ownership model places the highest burden on the builder at the onset stage of the technology adoption process. The builder

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32 Case studies may be downloaded at <http://eetd.lbl.gov/ea/ems/cases/>.

is primarily responsible for (1) initiating the technology adoption process, and (2) assuming the greatest capital investment risk. While the incentive design may mitigate the hurdles posed by the builder's initial capital investments, they do not necessarily mitigate the builder's capital risks in light of market fluctuations. Many builders were reluctant to participate in this project given the current conditions in the California housing market. The demonstration project faced financial challenges selling higher-priced solar homes in an inland community experiencing a drastic downturn in the new home market.<sup>33</sup>

- Accurate cost/benefit analysis is difficult to achieve. The financial impacts of integrating energy efficiency and residential PV must be understood by the entire design team early in the design process so as to inform better decision-making. Failure to do so can significantly increase stakeholder risk and jeopardize adoption. The reality, however, is that accurate cost/benefit analysis and assessment are very complex and often difficult to achieve. It thus becomes equally difficult to create a message and transfer value to the potential homebuyer. Oversimplification of true cost or savings can provide incorrect information and create skepticism in the market.
- Potential homebuyers need better information on the impact of utility rates. Utility rate complexity is a major impediment to accurately assessing and establishing a cost/benefit scenario. By failing to offer accessible information regarding the utility rate choices and impacts of those choices on energy efficiency and/or PV integration, alternative utility rate schedules can do more harm than good in the market. This has the potential to undermine consumer trust and confidence in new technology adoption.
- It is critical to fully identify all potential stakeholders and solicit their participation and feedback. The project team learned at a less than optimal date that the city of Lancaster's building department had no experience with net-metered PV installations.

The full report of this research is referenced in Appendix VII.

### **3.3.2. Recommendations**

The project team recommends the following for utility business models for zero-energy new homes:

- Consider alternatives to rooftop-mounted PV in residential sector applications. SMUD's Solar Shares program allows all customers to purchase shares of PV-generated electricity from one-megawatt solar farms. The NSHP, as currently designed, provides incentives for only the purchase of rooftop PV applications.
- Review the attributes that led to the success of the German model for application in California, and monitor what is happening in the state of Washington and in the Berkeley FIRST Program.

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<sup>33</sup> The author of this report notes that several communities have successfully created value and sold homes with solar as a standard feature. Those of particular note are Shea Homes San Diego at Scripps Highland and Clarum Homes' Vista Montana community in Watsonville, California. The sale of these homes, however, took place under different market conditions. Pardee Homes, on the other hand, offers solar, but only as an option for interested homebuyers.

- Comprehensive information about costs, benefits, risks, and savings are needed. Easy-to-use tools that yield accurate information for homebuilders and homeowners are needed.
- Solicit feedback from the participants of the NSHP, including PV manufacturers, homebuilders, homebuyers, and utilities.



## **4.0 Task 4 ZENH Demonstration**

### **4.1. Task 4 Approach**

The goal of this task was to support the building and selling of homes that meet the project design requirements developed in Task 2. The builder-partner would commit to participate by constructing the homes. The project team focused on providing training materials and training to the builder-partner's contractors and the sales staff. For the contractors, the training concentrated on ways to ensure the building envelope and mechanical systems were properly installed and performed as expected. For the sales staff, the training focused on the benefits of the energy efficiency measures and the PV system. The project team also would oversee commissioning activities and identify lessons learned for the energy efficiency measures or PV system.

Also, in-home displays were to be purchased and installed in the homes. The displays would provide real-time energy consumption information to the occupants, which could enable the project team to ascertain through surveys if continually seeing this information influenced the occupants' behavior.

The project team planned to coordinate with the builder-partner in preparation of marketing the ZENH community to the public, once the model homes were constructed.

ConSol developed the contractor and sales staff training materials and provided onsite training. AEC, Geltz Communications, and SCE provided support for the sales staff training. ConSol was responsible for the commissioning activities. AEC coordinated the installation of the home displays.

### **4.2. Task 4 Outcomes**

#### **4.2.1. *Status of Home Construction***

K Street East LLC, the builder-partner, intended to have 41 homes as part of this project, including three model homes. The three model homes were completed in October 2007. The next phase of construction, which included 14 homes, started in November 2007 and was to last no more than six months. The remaining 24 homes would be built in two phases. Construction for each phase was planned originally to take 120 days. However, due to the housing crisis and slowdown in the economy, only the first phase was completed in late 2008. Home sales were much slower than anticipated with only two homes sold and four more under contract as of December 2008. As of this writing, the last two phases have not been started. K Street is considering smaller floor plans and the PV system as an option rather than a standard feature.

Originally, the builder-partner anticipated selling the homes in the \$500,000 to \$600,000 range. However, due to market conditions, the asking price of each plan was reduced by \$50,000 in December 2007. The prices were further reduced in 2008 and ranged from \$350,000 to \$450,000.

### **4.2.2. Contractor Training**

The project team prepared training material that would help the builder-partner and the contractors to become familiar with constructing, testing, and documenting the optimized homes in terms of the following:

- Quality caulking and air sealing
- Quality installation of insulation
- HVAC installation procedures
- Building America Best Practices Guide
- ENERGY STAR® Thermal Bypass Checklist
- NSHP Photovoltaic (PV) System

The training material was used in trainings for the builder-partner's staff and for participating contractors before and during construction to ensure proper construction and best energy performance for the homes.

### **4.2.3. Solar and Energy Use Information**

#### ***Home Displays***

The project team planned to install in-home energy-use displays in all 41 homes at O Bel Sole as part of the demonstration phase. The displays would show PV generation and home electricity use information to the occupants. The home display systems require access to the Internet. (This would be the occupants' responsibility.) Figure 2 illustrates the type of home displays planned for each home.

**Figure 2. In-home display at one of the demonstration homes**



Source: Architectural Energy Corporation

The project team was interested in evaluating the concept that an in-home energy display would benefit the local utility by encouraging the home's occupants to reduce energy use by turning off lighting and appliances, or possibly shifting use to non-peak time periods. The influence of in-home energy displays on occupant behavior would involve comparing energy

use patterns and interviewing the homeowners of the project ZENH demonstration homes and a comparable community with conventional homes.

The in-home displays were installed in the three model homes; however, in November 2008, the research team discontinued the in-home display experiment and worked with the builder-partner to remove the displays from the model homes and refinish the walls.

### ***PV Performance Monitoring***

The PV systems at O Bel Sole are SunPower SunTile® BIPV products.<sup>34</sup> SunTiles blend quite seamlessly into flat and S-Tile roofs while generating electricity. This PV technology consists of high efficiency solar cells that can provide up to 50 percent more power per unit area than conventional cell technology.

SunPower Performance Monitoring was included with the SunTile products and offers easy access via the Internet to PV system data and performance.<sup>35</sup> The SunPower website enables viewing and charting PV system energy production, environmental effects, and electricity usage. However, it does not monitor in-home energy use.

#### **4.2.4. Market Information**

For this project, the project team gathered information about the residential market in Lancaster. According to the city website,<sup>36</sup> Lancaster has a population of approximately 130,000 residents. Antelope Valley has grown over 25 percent in the last decade to nearly 440,000 residents. Much of the Antelope Valley's growth over the last quarter of a century has been as a bedroom community for Los Angeles.

O Bel Sole is located at East Avenue K and 25th Street East. The homes were for move-up buyers looking for greater square footage and more amenities, not for first-time buyers. Most of the buyers were expected to come from the surrounding area, and it appeared that only one builder in the area had a similar-sized project. Table 8 provides the square footage, PV system sizes, energy efficiency measures, and initial sales price for the three model homes.

An August 2007 article in *Builder and Developer Magazine*<sup>37</sup> reported that Lancaster had approximately 2,500 residential units on the market and almost 24,000 units planned. The article rated the Antelope Valley area as one of the riskiest markets due to the number of planned units in closely located communities (e.g., Lancaster and Palmdale), the tightening of the lending standards, and the lower home prices occurring in more attractive areas closer to Los Angeles.

The median home cost in Lancaster had been around \$299,900. An Internet search in November 2007 found home prices ranging from \$325,000 to \$649,990.<sup>38</sup> An additional search showed 20 new home communities within the city of Lancaster.<sup>39</sup>

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34 <http://www.sunpowercorp.com/Products-and-Services/Residential-Solar-Roof-Tiles.aspx>.

35 Customers are able to log into the Internet to view performance at [www.sunpowermonitor.com](http://www.sunpowermonitor.com).

36 <http://www.cityoflanasterca.org/>

37 Southern California Real Estate Geography 101, Part I of III, Dennis Cisterna, *Builder and Developer Magazine*, [www.bdmag.com](http://www.bdmag.com), August 2007 issue.

38 [http://realestate.yahoo.com/California/Lancaster/Homes\\_for\\_sale/result.html;\\_ylt+AgwFXZ](http://realestate.yahoo.com/California/Lancaster/Homes_for_sale/result.html;_ylt+AgwFXZ).

**Table 8. O Bel Sole model homes information**

<b>MODELS</b>	<b>Plan A</b>	<b>Plan B</b>	<b>Plan C</b>
<b>Sq. Ft.</b>	2,800	3,218	3,533
<b>Solar Electric System Size</b>	2.3 kW DC	2.6 kW DC	2.8 kW DC
<b>Initial Sales Price</b>	\$450,000	\$500,000	\$550,000
<b>Revised Sales Price in 2008</b>	\$350,000	\$400,000	\$450,000
<b>Energy efficiency features</b>	Increased insulation R-21 walls/R-49 ceilings 92% energy-efficient furnace 16 SEER HVAC system Triple pane windows Radiant Barrier Energy-efficient lighting Tankless water heaters Third-party testing and verification		

Source: Architectural Energy Corporation

K Street's Jennie Stabile reported that she was using Countrywide Mortgage to provide home loans to qualified buyers. At the time, Countrywide was providing a loan at a rate somewhat lower than the market rate. It is important to note that the subprime mortgage crisis negatively impacted Countrywide, and, subsequently, Bank of America acquired Countrywide.

#### **4.2.5. Sales Training**

For the demonstration project, the team assisted K Street in developing information and activities to educate homebuyers and sales agents about the energy efficiency and PV features and benefits of the homes. The sales and marketing materials were based in part on the NSHP program, which began in 2007.

The first sales agent training took place on September 2007 at the SCE Antelope Valley Service Center in Lancaster. The training was specifically directed at the sales team, but unfortunately attendance was low. Five agents were to be trained, and only three attended. Of those three, only two actually became agents. The daylong training, therefore, was an expensive venture. A continuation of the training followed in October 2008, the day before the grand opening, with one more agent in attendance. However, he stayed on the project only a few weeks.

Sales agent turnover is always a problem, whether from a seasoned production builder or a new-to-the-market group such as K Street East LLC. Ongoing training for current and future sales agents, re-enforcing previous efforts, would be needed. However, it was determined to be too expensive and time-consuming, given poor sales and high sales agent turnover. For the NSHP program, other training options such as Internet-based or energy center trainings should be considered.

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39 Google Maps – new homes in Lancaster, California: <http://maps.google.com/maps?hl=en&ie=UTF8&q=new+homes&near=Lancaster,+CA&fb=1&view=map&cd=1>.

A brief discussion of the training areas follows.

### ***SCE Utility Rate Tariffs***

How and when a homeowner uses electricity in a home affects the SCE utility rate tariff selection that best lowers electricity bills. There are several options that require the home occupants to know their usage patterns including what time of day they use the most energy. It is important for sales agents to understand the options because they must help the new buyer decide which rate tariff to select. SCE developed a document for the sales agents to give prospective homeowners. Homeowners should initially sign up for the basic domestic rate plan. Within six months to one year, homeowners should be able to have an idea of what their consumption patterns are so they may select the best SCE utility rate tariff option.

### ***NSHP and California Green Builder (CGB) Program***

O Bel Sole worked to qualify homes under both the NSHP and the California Green Builder (CGB) programs. Sales agents learned the major highlights of both programs and viewed a video tour<sup>40</sup> providing information about energy efficiency, proper protocols, and inspections.

### ***Inspections***

An individual representing the Home Energy Rating System (HERS) presented information about the inspections and diagnostics that take place during construction. Both the NSHP and CGB programs require inspections.

### ***Solar Electricity***

For PV, a SunPower representative took the agents through the features, benefits, and past history of sales for PV-equipped homes. Other topics included converting watts to other units, solar array orientation, monthly solar production, system components, and on-line viewing of system performance.

### ***Energy Metering and Anticipated Savings***

Sales agents were instructed how to discuss anticipated home energy savings (illustrated in Table 9) with potential homeowners, including end-use metering, which was planned for some of the homes as part of this PIER project. Agents also learned about the in-home energy displays, monthly data from the SCE utility meter, homeowner surveys, and homeowner agreements. A copy of the homeowner end-use metering agreement is provided in Appendix IV. As part of the training, sales agents needed to understand that the first 15 homeowners would be asked to participate in the end-use metering study and would need to sign the end-use metering agreement.

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40 The video can be seen at the following website: <http://www.comfortwise.com/tour/comfortwise.htm>.

**Table 9. Projected electric and gas bill cost savings under SCE's Schedule D rate tariff**

<b>Plan A - Schedule D Rate Structure</b>	
<b>Total Annual Electric Bill Reduction (T-24 - NSHP Home) =</b>	<b>\$1,435.36</b>
<b>Percent Reduction from T-24 Home =</b>	<b>61%</b>
<hr/>	
<b>Total Annual Energy Bill (Electric + Gas) Reduction (T-24 - NSHP Home) =</b>	<b>\$1,706.96</b>
<b>Percent Reduction from T-24 Home =</b>	<b>54%</b>

<b>Plan B - Schedule D Rate Structure</b>	
<b>Total Annual Electric Bill Reduction (T-24 - NSHP Home) =</b>	<b>\$1,733.44</b>
<b>Percent Reduction from T-24 Home =</b>	<b>64%</b>
<hr/>	
<b>Total Annual Energy Bill (Electric + Gas) Reduction (T-24 - NSHP Home) =</b>	<b>\$2,052.67</b>
<b>Percent Reduction from T-24 Home =</b>	<b>56%</b>

<b>Plan C - Schedule D Rate Structure</b>	
<b>Total Annual Electric Bill Reduction (T-24 - NSHP Home) =</b>	<b>\$1,844.19</b>
<b>Percent Reduction from T-24 Home =</b>	<b>64%</b>
<hr/>	
<b>Total Annual Energy Bill (Electric + Gas) Reduction (T-24 - NSHP Home) =</b>	<b>\$2,151.92</b>
<b>Percent Reduction from T-24 Home =</b>	<b>57%</b>

Source: Architectural Energy Corporation

### ***Mortgage Update***

The mortgage industry had been in a state of upheaval, and when the training took place, Countrywide Mortgage was front and center in the discussion. At the time of the training, Countrywide provided a variety of fliers about reverse mortgages, the California HFA (Housing Finance Agency) interest rate schedule, loans for green homes and energy-efficient homes, and Homeownership Program Sales Price Limits.

It was important for the sales agents to understand that energy-efficient mortgages typically allow homebuyers to qualify for larger loans on the premise that buyers can afford higher monthly payments because of the amount saved on monthly utility bills.

#### **4.2.6. Commissioning Activities**

The commissioning activities planned for this project did not occur due to the lack of home sales after the model homes were completed. ConSol did perform training for the builder's subcontractors, which included a discussion about the commissioning of home energy systems and best construction practices. However, the team was unable to compile a list of lessons learned from actual commissioning activities of O Bel Sole homes.

### **4.3. Task 4 Conclusions and Recommendations**

#### **4.3.1. Conclusions**

When optimized homes are built to a higher standard, builders and contractors can reduce callback problems, improve overall building performance, and increase customer satisfaction.

At the same time, homeowners enjoy increased comfort, performance, and quality, and reduced energy bills. Through proper installation practices and documentation, builders and contractors can play a key role in constructing homes that reduce energy needs for operating the homes. These benefits have been reported in other studies. For this project, the team was unable to further these findings.

The Task 4 activities provided the following conclusions:

- Confusion developed among the city employees, ConSol, SunPower, and SCE about the required documentation and inspection of the PV systems. The confusion resulted in delayed permitting of the model homes.
- The typical way production builders market is quite different from small builders like K Street East LLC. Where major builders are interested in promoting their communities as soon as possible in order to establish a wait list, K Street East LLC was more cautious about keeping its project quiet until the grand opening. Also, grand opening and marketing costs are absorbed by production builders, while this builder-partner required the help of sponsors and the PIER project team. A typical production builder would have a stable sales force from which to draw. K Street East LLC relied on connections in the real estate industry. This meant that the PIER team trained individuals who would not necessarily become K Street agents, and individuals who would become K Street agents missed training.
- The project team had hoped to explore ways to create a larger role for investor-owned utilities in marketing these innovative types of homes. In this project, the utility was marginally involved in marketing these energy-optimized homes. In general, the marketing burden for high-performance homes continues to be mainly on the builders. Future projects need to create opportunities for investor-owned utilities to be more involved and invested.
- The potential homeowner traffic through the models was encouraging and consistent after the grand opening. However, one of the sales agents said many people who come through were not well-versed on PV systems or, for that matter, on many of the energy-efficient features of the homes. It helped that each of the model homes included a home energy display. However, it indicated the strong need for a public education campaign, at least in this part of California.
- The Energy Commission had not fully launched the marketing material or public relations campaign for the NSHP when O Bel Sole came onto the market. As California homeowners and homebuilders recognize the NSHP brand and understand the technologies, and the economic crisis lessens, the sales of energy-efficient homes equipped with PV systems should increase.

The full reports for contractor training, the homes displays, and sales and marketing training, resulting from this research are referenced in Appendix VII.

#### **4.3.2. Recommendations**

- Expand statewide public education efforts for the NSHP program so 2016 PV deployment goals can be met.

- Clearly differentiate for homebuilders and potential homeowners the numerous energy efficiency and green building programs, such as NSHP, ENERGY STAR, Green Builder Program, and others.
- Train and educate all stakeholders involved with energy-efficient homes with PV systems, including homebuilders, homeowners, local building departments, real estate agents, and lending institutions.
- Engage utilities to more fully participate and invest in PV deployment and market models.

## **5.0 Task 5 ZENH Monitoring and Evaluation**

### **5.1. Task 5 Approach**

The goal of this task was to evaluate the performance of at least 15 of the demonstration homes to determine the extent to which they met the performance and energy cost goals of this project. The team's approach was to develop a protocol for selecting the homes, install the instrumentation, and monitor energy use for one year with occupants in the houses. The team would gather utility data. The team also would find a group of conventional homes of similar size in the same climate zone, collect utility data about them, and compare those data to the data from the demonstration homes in the same period of time.

The PIER demonstration homes would have end-use monitoring equipment integrated into the design ensuring that air conditioning and other equipment were installed properly and worked as designed during the monitoring. The project team would survey the occupants to document their experience and knowledge about their energy-efficient and solar energy homes.

The project team would monitor end-use electric power in the 15 demonstration homes at one-minute intervals for the following: 1) kitchen appliances, 2) HVAC units, 3) interior lighting, 4) the whole house via utility meter reading, and 5) the PV system.

The SCE utility meter would record whole house electric power at 15-minute intervals in the 41 demonstration homes for one year, beginning spring 2008 and depending on the rate of construction and sales. Whole-house electric power would be similarly monitored in an equal number of occupied conventional homes for one year. SCE identified a community of similar-size conventional homes in close proximity. The project team intended to collect gas utility billing data for each month during the one-year monitoring period. This was contingent on gaining written permission from the homeowners. SCE intended to monitor the distribution circuits for both communities under Task 7 activities.

AEC would be responsible for the instrumentation, data collection, and analyses. SCE would work with AEC to find a similar community of conventional homes in the area, and to provide utility data for both communities during the course of the year.

### **5.2. Task 5 Outcomes**

#### **5.2.1. Selection of Homes**

Originally, AEC planned to install end-use monitoring equipment in a representative number of each house plan based on the different construction phases. The home locations for each plan (A, B, and C) were randomly selected by phase. Due to the extreme slowdown in the housing market in California, which affected both the construction schedule and sales at O Bel Sole, AEC shifted the selection process to monitor the first 14 homes built in 2008. This approach, which was presented and approved by the Commission staff in December 2007, provided the best opportunity to gather as much end-use energy data as possible on 15 homes before the project concluded in the spring of 2009.

However, the lack of sales and occupied homes severely crippled this effort. Only two homes sales were recorded through December 2008. AEC was able to monitor one of the model homes, which was used as a sales office by the builder-partner.

### **5.2.2. Monitoring**

The AEC team anticipated collecting the following monitoring points. The team's preference was to use a one-minute recording interval, summarized at a 15- minute interval.

- Weather station for entire subdivision
  - Dry Bulb Temp, Relative Humidity, Wind Speed, Solar Radiation, Rain Gauge
- Whole house electric use and demand (kW and kWh)
- HVAC electric use and demand (kW and kWh)
- Lighting electric use and demand (includes interior and exterior) (kW and kWh)
- Major appliance electric use and demand (refrigerators, cook tops, ovens, clothes washer) (kW and kWh)
- PV unit output (kW and kWh)
- Solar radiation at each PV installation (watts per square meter)
- Gas data (based on gaining homeowner's permission) (therms and/or BTUs)

AEC also identified the need for additional wiring for the data acquisition system and home display, the installation of instrumentation enclosures, and the installation of attic temperature sensors.<sup>41</sup> The team completed the following tasks:

- Developed the enclosure installation and wiring documentation package for the onsite electrician.
- Developed the detailed metering plans (mapping of circuits) for the three different home models.
- Assembled, configured, and tested the 15 metering systems.
- Coordinated commissioning with field installation crews and configured the remote data acquisition for each home.
- Coordinated shipping of metering and display equipment as required for anticipated installation schedules.
- Resolved equipment and Internet data access performance and maintenance issues.
- Developed and implemented plans to remove equipment at the end of the project.

The plan was for each homeowner to sign an agreement allowing the project team to maintain the monitoring equipment. The agreement is shown in Appendix IV. AEC would install and commission the monitoring equipment and set up the data acquisition website to archive data for analysis. AEC installed an end-use monitoring equipment panel (Figure 3, right image) and a weather station (Figure 3, left image) at one of the model homes. A screenshot of AEC's Web data is shown in Figure 4.

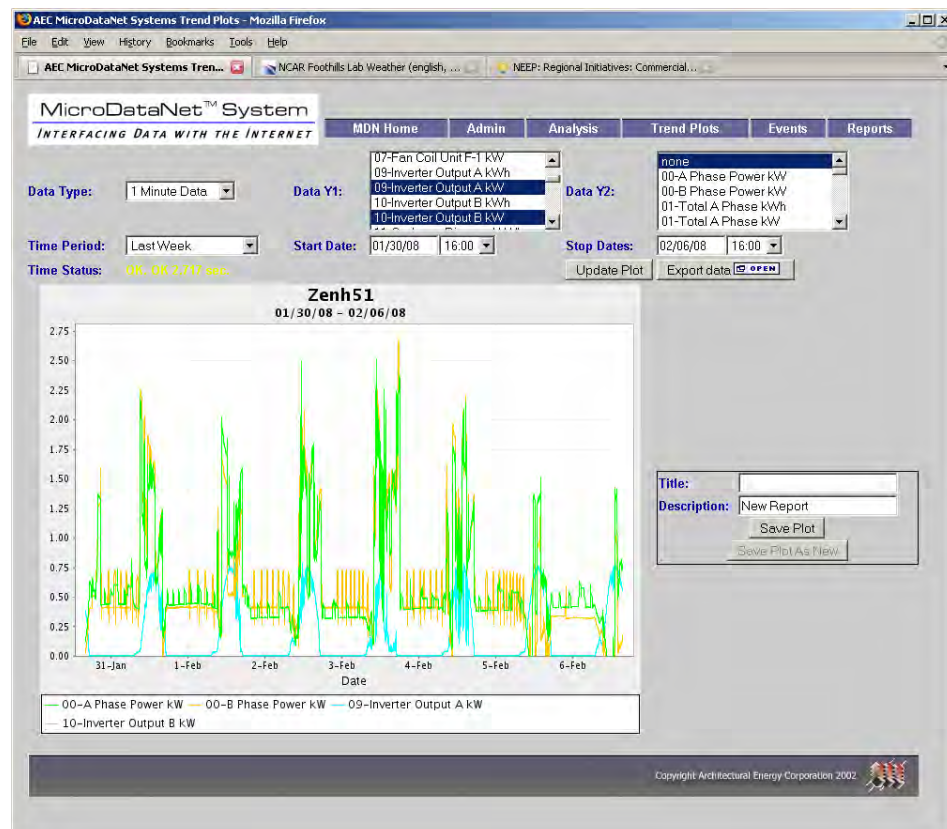
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<sup>41</sup> Attic temperature sensors were added to this project at a nominal cost and would have provided valuable data in support of a separate PIER project, conducted by ConSol.



**Figure 3. Weather station and monitoring panel**

Source: Architectural Energy Corporation



**Figure 4. Data is viewable via the Internet from the O Bel Sole model home**

Source: Architectural Energy Corporation

The electrical installation of circuits in the garage, including a heat pump, for the sales offices was not complete before the grand opening. Solar electric production from the PV array was not on-line until shortly after the beginning of 2008 due to building permit and utility interconnect paperwork issues that were resolved in early January. In mid-February, the garage electrical circuits, including the heat pump, were added to the monitored electrical channels.

### 5.2.3. Resulting Data

AEC collected the model home end-use energy data from March through September 2008. The Model A home, located at 43507 Serenity Court, houses the sales office in the garage. This space would normally have very small plug loads, but instead it supported multiple computers, monitors, lights, and its own heating and cooling heat pump during the seven-month monitoring period. Table 10 summarizes the energy performance of the entire house, including the garage.

**Table 10. Monitored Energy Performance Summary**

ZENH Lot 21 Statistic Summary, March-September, 2008

	March	April	May	June	July	August	September	7-Month Averages
Average Daily House Consumption (kWh)	26.7	17.5	19.3	30.0	42.2	47.9	32.3	30.8
Average Daily Solar Production (kWh)	10.9	13.1	13.7	14.1	13.0	11.6	9.6	12.3
Max Daily House Consumption (kWh)	39.9	27.8	59.5	68.4	78.1	104.9	83.9	
Max Daily Solar Production (kWh)	13.3	14.3	15.8	15.6	14.3	13.4	11.5	
% Solar Electric	41.0%	75.0%	71.0%	46.8%	30.8%	24.3%	29.9%	
Solar to Grid (Running Monthly Total kWh)	40.3	158.1	169.8	171.0	111.6	91.3	95.2	
House Consumption (Running Monthly Total kWh)	828.5	525.7	599.8	900.5	1306.7	1484.5	967.5	944.7
Total Solar Production (kWh)	337.0	392.4	423.3	421.8	401.8	360.4	289.4	375.2
% Solar Utilization by House	35.8%	44.6%	42.3%	27.9%	22.2%	18.1%	20.1%	30.1%
Total Monthly Rainfall (in)	0.04	0.01	0.03	0	0	0	0	
Average Monthly Windspeed (mph)	11.7	11.6	11.8	11.4	9.4	9.7	5.7	
Max Windspeed (mph)	35.7	35.3	36.1	35.5	28.9	31.8	25.4	
Average OSAT (°f)	53.1	58.0	64.6	78.2	83.3	83.0	75.8	
Max OSAT (°f)	78.3	88.7	99.9	102.8	108.5	105.1	100.9	

Average Solar Fraction based on monthly kWh solar production vs. usage

39.7%

Source: Architectural Energy Corporation

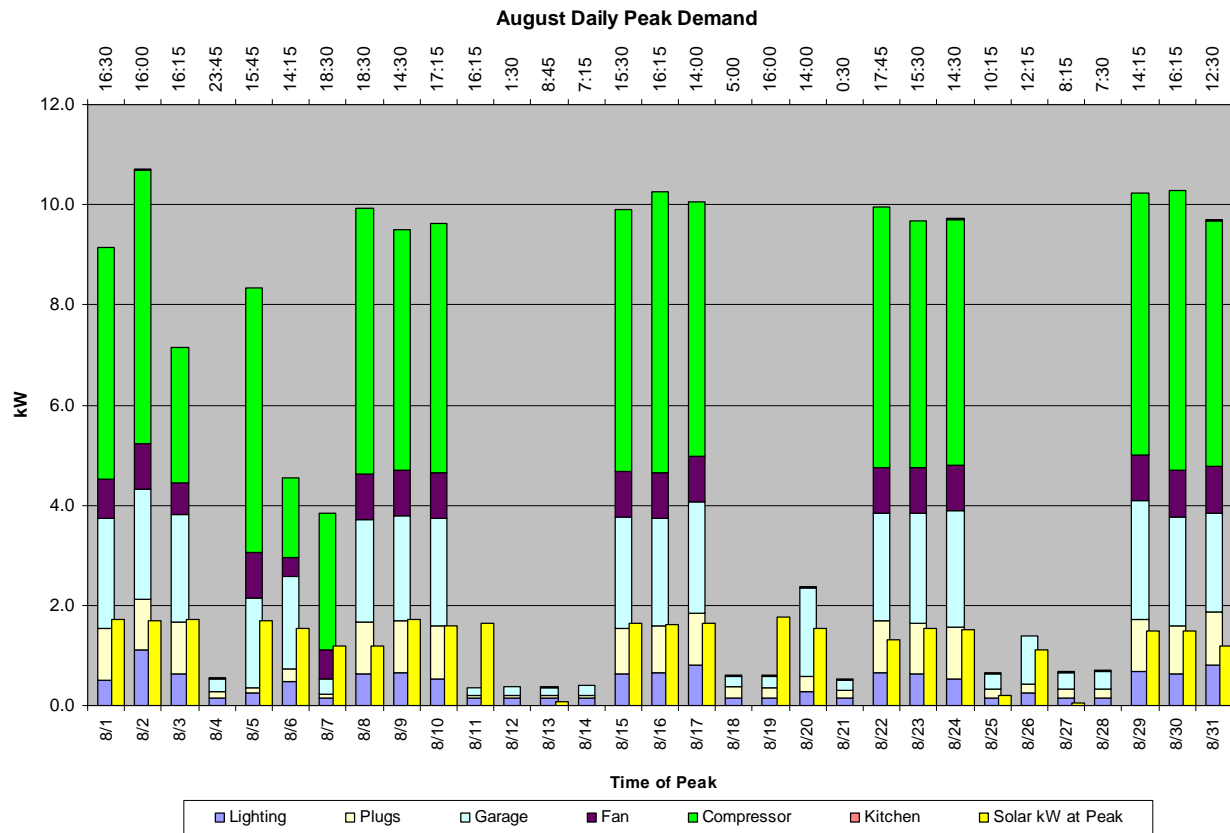
In particular, the 15-minute peak demand exceeded 10 kW five days in August when the sales office was open in the afternoons. The peak demand occurred from 2:15 to 4:45 P.M. The majority of the power was used by the home's central air-conditioning (AC) system, followed by the garage loads. Figure 5 shows that the sales office was usually open on Fridays, Saturdays, and Sundays during August, but it appears that it was open for a few hours on other days as well. To save energy, the sales staff intended to disable the AC except during occupied days. However, the AC ran continuously from midday on the fifth until the night of the seventh. On unoccupied days without AC, solar electricity met all of the home's electric loads.

Energy consumption in August was close to 180 kWh more than July due to a higher number of days that the sales team was present and turned on the AC. The data show AC use on 18 August days resulting in 720 kWh of energy consumption in August, an increase from 578 kWh in July.

The PV system generated 360 kWh, supplying the equivalent of about 24 percent of the 1485 kWh of total consumed power in August. On days when the sales team was absent, the PV

system produced a total of 91 kWh more than the house's consumption. The amount of electricity from the PV system in August (360 kWh) fell by 40 kWh from July and 60 kWh from June; in September, solar production dropped to 289.4 kWh.

The dominant end use was the home's AC followed by the garage loads, lighting inside the home, and the home's plug loads.



**Figure 5. August 2008 power use at peak demand**

Source: Architectural Energy Corporation

## 5.3. Task 5 Conclusions and Recommendations

### 5.3.1. Conclusions

Task 5 activities provided the following conclusions:

- The monitoring data from the Plan A model home showed a higher energy and demand use than the project team predicted with simulation software. Monitored data in July and August indicated the model home reached a 10 kW demand on several occasions. Predicted levels had been estimated to be less than 5 kW. The project team had not anticipated that model home's garage would serve as the sales office with the addition of a heat pump and miscellaneous office equipment in the garage.
- The project team was unable to monitor the end-use energy performance of 15 homes due to extremely slow home sales during the duration of the project.

The full reports of this research are referenced in Appendix VII.

### **5.3.2. Recommendations**

- Conduct further research of end-use energy performance beyond-energy code new homes. This information will verify the actual energy and demand savings from energy-optimized homes with PV systems, quantify the impact of occupant behavior, and inform the accuracy of energy simulation models.

## 6.0 Task 6 ZENH Market Sustainability

### 6.1. Task 6 Approach

The goal of this task was to develop the necessary information to design a utility pilot program that would enable the project concept to transition from a demonstration test to full-fledged market sustainability. The team's approach was to design the structure for a utility-sponsored program that promotes the construction and purchase of optimized energy-efficient homes with PV systems. The program would be designed to be sustainable in the marketplace, standardize the involvement of the market participants, and provide consistent energy performance.

Geltz Communication (Geltz) was responsible for designing the strategy, branding, and associated marketing materials. SCE would consider a utility-sponsored ZENH program. All of the project team, including representatives of the Energy Commission and SunPower, the PV-partner, would provide support during the marketing activities for the builder-partner demonstration homes.

### 6.2. Task 6 Outcomes

The project team worked with K Street East LLC and SunPower Corporation to develop a detailed marketing plan that served as a road map for this demonstration project. During the course of several meetings, the group collaborated to develop the message, the collateral, the signage, the website, recommended events and training, and the qualitative assessments. Geltz developed the branding for the demonstration project, which included the O Bel Sole name, logo (see Figure 6), color scheme, the actual creative development of the marketing documents, and the coordination of the grand opening event. Their team created a CD-ROM that includes the O Bel Sole marketing materials and delivered it to the Commission.



**Figure 6. Name and logo for the PIER demonstration project**

Source: Architectural Energy Corporation

The project team discussed a July 2007 groundbreaking ceremony. However, the group decided that the model homes should be finished for the public to tour and changed the event to a grand opening. The team chose September 20 but later changed to October 4 due to delays in

completing the model homes. The event included tours of the model homes and various speakers. The project team, along with Jenny Stabile (head of K Street East LLC, the developer) and Byrne & Byrne (the builder), contributed names for the invitation list. The list included local government officials, the Association of Realtors, Chamber of Commerce members, Home Builder Association officers, participating trade contractors and product manufacturers, local magazines, local and regional newspapers, local and regional news stations, US DOE officials, local government and congressional representatives, involved utilities, interested buyers, building inspectors, and national and local dignitaries.

Marketing materials developed for the grand opening included a press kit, interpretive interior signage about the sustainable features of the model homes, a billboard announcing the community, and a brochure with the energy efficiency and solar energy features and benefits. Geltz sent electronic invitations in August and September to invitees announcing the event. In order to defray the costs of the grand opening, sponsor partners were sought. Table 11 lists the sponsors and their contributions.

**Table 11. Match funding for grand opening**

<b>Company Name</b>	<b>Sponsorship Amount</b>
Bacco Mechanical, Inc.	\$250
Goodman Manufacturing Company, L.P.	\$1,000
Byrne & Byrne Construction	\$250
Southern California Edison	\$500
Countrywide Mortgage	\$1,000
SunPower	\$750
Geltz Communications	In-Kind Contribution: Interior Signage and Features & Benefits Collateral Piece
Rinnai	1 tankless water heater
Architectural Energy Corporation	\$500
ConSol/Comfort Wise	\$500
<b>Total</b>	<b>\$4,750</b>

Source: Architectural Energy Corporation

Geltz contacted media outlets and sent a press release. Media contacts included KABC-TV (Los Angeles ABC affiliate), KCAL (Los Angeles CBS affiliate), *Antelope Valley Press*, *Sunset Magazine*, *Los Angeles Times*, and the *Los Angeles Times'* Valley Real Estate supplement. *Antelope Valley Press* ran an article about O Bel Sole's participation in the NSHP. The release is shown in Appendix V.

The grand opening event was a success with more than 100 people attending. Speakers included the following individuals: 1) Donald Frey, Executive Vice President of Architectural Energy Corporation, 2) Jennie Stabile, President, K Street East LLC, 3) Al Stabile, Vice President, K Street East LLC, 4) David Byrne, Principal, Byrne & Byrne General Contractors, 5) Claudia Chandler, Assistant Executive Director, California Energy Commission, 6) Gregg Ander, FAIA, Chief Architect, Southern California Edison, 7) Addison Marks, Builder Account Manager, SunPower Corporation, and 8) Henry Hearn, Mayor, city of Lancaster. The main invitation is shown in Figure 7, and several photographs from the event are in Figures 8 and 9 including the billboard, participants, speakers, a model home showing the PV roof tiles, and the SCE energy efficiency mobile unit.



**Figure 7. Electronic invitation for O Bel Sole grand opening event**

Source: Architectural Energy Corporation



**Figure 8. O Bel Sole Grand Opening Event Billboard and Various Participants**

Source: Architectural Energy Corporation



**Figure 9. More O Bel Sole grand opening event speakers, model home, and SCE energy efficiency mobile unit**

Source: Architectural Energy Corporation

On October 15, 2007, the national polling firm Public Opinion Strategies found in a survey that the following were the top comments when those surveyed were asked what would affect their decision to either purchase a new green home or remodel their current home: 1) reducing energy costs, 2) living in a healthier home, and 3) doing the right thing for the environment. The themes for the marketing collateral, chosen by the PIER project team and builder-partner, reflect these findings:

- Come home to a brighter environment
- Live better, live green, live for less
- Cut your electric bill in half
- Better quality, move up home
- More home, less energy costs

The builder-partner wanted to be first in Antelope Valley with solar energy systems, first with tankless water heaters, and first with a green community. Jennie Stabile felt that promoting

energy efficiency, solar electricity, and a green community would help the homes sell faster. Specific marketing materials that were produced and used for both short- and long-term marketing activities include the following:

- O Bel Sole Brochure
- Features & Benefits Collateral Piece (see example in Appendix VI)
- Solar Energy System Collateral provided by SunPower Corporation
- Mortgage Collateral provided by Countrywide Mortgage
- Energy Efficiency Collateral provided by SCE
- California Green Builder Program information provided by CGB
- Web site for demonstration homes – [www.obelsole.com](http://www.obelsole.com)

Each of the model homes had displays showing the electricity consumption and production that garnered much interest from prospective homebuyers. Many individuals commented positively about the ability to easily track electricity use on a daily basis using the displays.

The project team had planned additional marketing and branding materials and homeowner surveys (several months after occupancy) as part of this task. The team had also intended to analyze end-use metering and utility metering data. With only two hours sold in 2008 in O Bel Sole, the team discontinued these efforts.

## **6.3. Task 6 Conclusions and Recommendations**

### **6.3.1. Conclusions**

Task 6 activities yielded the following conclusions:

- Though the traffic through the models was consistent after the 2007 grand opening, one of the sales agents said many people who came through the homes did not understand what they were looking at. They were not well-versed on solar or, for that matter, many of the energy-efficient features of the homes. It helped that each of the model homes included signage and a home energy display. However, it indicates the strong need for an education campaign and marketing materials about both energy efficiency and renewable energy technologies, geared toward the audience.
- The NSHP collateral material was not readily available during 2007. The NSHP guidelines became available in early 2008. However, they focused on technical criteria and forms required for participants to meet the NSHP program requirements. A strong need exists for collateral material with a more educational focus. As a side note, it seems that most solar companies submit the NSHP paper work for the homebuilders.
- Because SCE was in the midst of becoming a qualified program implementer for the NSHP, and also offered the California ENERGY STAR New Homes Program, it was not clear to the project team how this PIER project would be used to create and launch another utility branded program. Clearly, the NSHP and SCE's ENERGY STAR New Homes Program had already been approved through the California Public Utility Commission and successfully launched.

The full report of this part of the project is referenced in Appendix VII.

### **6.3.2. Recommendations**

- Conduct a statewide education campaign and produce marketing materials about both energy efficiency and renewable energy technologies, integrated with the NSHP and SCE's California ENERGY STAR New Homes Program efforts.
- Produce collateral material focusing on features and benefits, brief success stories, prescriptive measures for energy efficiency, and basic PV system documents; these were not part of the NSHP offering in 2008. However, this type of marketing material would help to sell the NSHP concept to homebuilders, potential homeowners, and real estate agents.
- Consider future marketing materials that include the following:
  - "Dare to Compare" marketing pieces comparing conventional homes to high-performance homes with documented testimonials. Include cost analysis/energy savings fact sheet using rate tariffs from investor-owned utilities (IOUs) and municipal utilities as appropriate, actual utility bills from homeowners<sup>42</sup> of NSHP homes, and homeowner comments about the quality of the indoor environment within the high-performance homes.
  - Additions to the NSHP website. Include virtual tours; information about water conservation strategies or sustainable building materials (which could simply link to other resources); examples of net-metering agreements from various utilities; and links to energy-efficient mortgage offerings.

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<sup>42</sup> According to McGraw-Hill Construction's *The Green Homeowner: Attitudes and Preferences for Remodeling and Buying Green Homes SmartMarket Report* produced in conjunction with the National Association of Home Builders, "Green homeowners are happy with their homes and are recommending them at rates significantly higher than recommendation levels of other industries." This report is available for a fee at [http://construction.ecnext.com/coms2/summary\\_0249-258442\\_ITM\\_analytics](http://construction.ecnext.com/coms2/summary_0249-258442_ITM_analytics).



## 7.0 Task 7 ZENH Utility Benefits

### 7.1. Task 7 Approach

The goal of this task was to determine the implications of installing optimized homes on a utility's electrical distribution systems. SCE was the main party responsible for this part of the project. SCE's Transmission and Distribution Business Unit would evaluate electrical distribution impacts at the distribution circuit level. The approach was to investigate and determine the candidate circuit serving O Bel Sole in Lancaster and evaluate electrical system impacts based on the potential benefit to the system. SCE's team would identify two comparable circuit segments (radials) carrying residential loads. One radial would have conventional homes, and the other would have the O Bel Sole demonstration homes. SCE would instrument each radial and its distribution transformers to collect data that would allow the benefits, principally peak shaving, to be evaluated by direct comparison.

The project team considered the following electrical system concerns:

- Damaging effect of harmonics
- Low power factor
- Excessive voltage fluctuations
- Unacceptable unbalanced load

If the PV systems on the homes were connected as single-phase, some power quality issues needed to be addressed. One issue was excessive harmonics, which can cause transformer overloading, excess neutral currents, and harmful neutral-to-ground voltages. PV systems typically help the local power factor because of reduced loading behind the nearest capacitor bank. Also, some PV systems can improve power factor with the use of more expensive inverters.

Voltage fluctuations also can be an issue. Fluctuations may occur when clouds rapidly pass over PV modules, subjecting them to cycling. Rapid cycling may cause some PV units to trip offline. For single-phase PV units, if more units happen to be connected to one particular phase below a transformer, unbalanced loading can result causing electrical cables to overheat and PV systems to trip offline.

SCE determined that the following data needed to be obtained for a comprehensive study:

- 15-minute kW and kVAR (kilovolt-ampere reactive) use
- Time of peak for kW and kVAR
- Power factor at the meter
- Total harmonic distortion at the service transformer
- Neutral current effects

TOU meters could measure the data necessary for the first three items. SCE's Power Quality (PQ) group would measure the last two items locally at selected times and intervals. If the ZENH homes were not evenly connected to the distribution system, there may be an imbalance situation resulting in higher neutral currents that SCE also would have the PQ group investigate.

## **7.2. Task 7 Outcomes**

When this project began, SCE hoped to have the O Bel Sole demonstration homes and the conventional homes on separate distribution branch or feeder circuits. Thus, the cumulative effects of the energy efficiency measures and the PV systems on the circuit would be easily measured and the results compared to the baseline homes. Rocky Mountain Institute (RMI) was commissioned to determine the number of homes that needed to be metered to ensure that the data was statistically reliable and not skewed by various factors. The evaluation period would be two years and would start when the demonstration homes were built and occupied.

However, due to the extreme slowdown in the housing market in California, which affected both the sales and construction schedule at O Bel Sole, SCE changed course and planned to monitor all of the demonstration homes built in 2008 and a similar number of conventional or “control” homes. The number of homes to be monitored would be fewer than originally planned, reduced from 75 to 41. The two data sets (O Bel Sole and control homes) would still be on different feeder circuits, but the number would be too minimal to be statistically significant. However, SCE and the project team still believed this approach provided the best opportunity to gather as much distribution circuit data as possible, given the circumstance. The resulting information could still yield important insight for the utility into the potential impact of energy efficiency measures combined with PV systems on utility distribution circuits.

For this task, SCE researched several areas including congestion issues, selection of a control community, metering options, and required customer/utility agreements. A brief discussion of each follows:

### **7.2.1. Congestion**

In determining candidate circuits for evaluating system impacts, SCE needed to take circuit congestion into consideration. Congestion is defined as the overloading of a section of a transmission or distribution line by a combination of transmitting electricity for various contracts and supplying other customer loads. An optimized-home development, like O Bel Sole, or groups of optimized-home developments have the potential to lower the total load in an area. The typical SCE distribution circuit design is twenty-one 2,400 sq. ft. homes per 75-kVA mini-pad transformer. The homes in the O Bel Sole development would be much larger, so fewer homes per transformer were planned or the transformers would be higher capacity. Typical residential customer loads peak in the early morning hours from 6 a.m. to 8 a.m. and late afternoon hours from 4 p.m. to 8 p.m. PV production of electricity typically peaks during mid-day to early afternoon so the peaks would not be coincidental. SCE assumed that any excess generation from the PV would feed into the system and be utilized by neighboring homes, which would lower the total demand in the area. The data from this project would help determine how effective high performance residential communities could be to reduce congestion if concentrated near a congestion area, especially during summer peak demand periods.

### **7.2.2. Selection of Control Community**

The circuit serving the 41 homes in the O Bel Sole community would be monitored. For the conventional or control community, SCE service planners reviewed new residential developments in the Lancaster and Palmdale area to select an appropriate choice. They used the criteria that the homes be similar in size to K Street East LLC and be built according to 2005 Title

24. The following developments were identified: 1) Tract 62695: 42 Lots – 2800 sq. ft., N-8 Avenue/ Rancho Vista, Palmdale, 2) Tract 43689: 46 Lots - 2700 sq. ft., Avenue P/ 11th St W, Palmdale, 3) Tract 60858: 44 Lots - 3400 sq. ft., 42nd St West/ Avenue I, Lancaster, and 4) Tract 60003: 35 Lots - 2600 sq. ft., Ave J-8/ 61st West, Lancaster.

Given that the average size of the K Street East homes was to be 3,203 sq. ft. and include 41 homes, Tracts 62695 and 60858 were selected for further investigation. An SCE engineer inspected both tracts to determine the practicality of monitoring the local distribution circuit. This investigation looked at issues such as these:

- Would the existing circuit be changed to underground cable under Rule 21,<sup>43</sup> which means reinstalling metering equipment at some point?
- Were the transformers accessible and would they accommodate metering equipment?
- Would permits be required to access transformers on private property?
- Was there potential for new developments around the tract that might hook into the circuit during the project period?
- Could the usage of the homes in the tract be isolated?

Tract 62695 (Rancho Vista) in Palmdale was selected for further research as the control community. The builder for Rancho Vista was Beazer Homes, who proved very helpful in providing information on the homes. Beazer Homes representatives were not informed about overall goals for this PIER project but were told that the project results would be shared with them and would potentially contribute to their ability to design more efficient homes in the future. Table 12 compares building attributes of both communities.

Rancho Vista appeared to represent minimally compliant construction although many appliances were ENERGY STAR certified. A walkthrough of the development did not reveal any existing PV or solar thermal systems. All but two of the homes appeared occupied, and two homes appeared to have been recently sold. One significant issue with the use of Rancho Vista as the control community was the reduced square footage of several homes. However, this community was the best option. SCE planned to place TOU meters on a sample of the Rancho Vista homes. Additionally, the project team planned to distribute homeowner surveys, which would further add to the knowledge base.

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<sup>43</sup> Rule 21 describes the interconnection, operation, and metering requirements for generating facilities to be connected to SCE's distribution system. The California Public Utilities Commission has jurisdiction over this rule. Subject to the requirements of this rule, SCE would allow the interconnection of generating facilities to its distribution system

**Table 12. Building attributes comparison**

	<b>O Bel Sole</b>	<b>Rancho Vista</b>
Appliances	ENERGY STAR	ENERGY STAR
Air Conditioner	16 SEER	13 SEER
Wall R Value	21	13
Ceiling R Value	49	38
Radiant Barrier	Yes	Yes
Title 24 Compliant	Exceeds 2005	Built to 2005
Windows	.20 U-value .22 SHGC	.45 U-value .45 SHGC *
Hot Water system	2 Tankless .82 Energy Factor	Standard
Number of Homes	Plan A: 15 Plan B: 8 Plan C: 18	14 of each plan
Square Footage	Plan A: 2800 sq ft Plan B: 3218 sq ft Plan C: 3533 sq ft Avg: 3203 sq ft	Plan A: 2100 sq ft Plan B: 2684 sq ft Plan C: 3163 sq ft Avg: 2649 sq ft
* Based on Title-24 2005 minimal requirements; not confirmed with Beazer Homes		

Source: Architectural Energy Corporation

### **7.2.3. Metering Process**

The meter installation and billing process would not be the standard SCE process for the 41-demonstration homes and the control community. Special TOU meters would have to be installed on the control homes, though the customer would see only a regular residential bill. SCE would apply special meter reading and billing provisions. The 41-demonstration homes also would have the TOU meters installed but would be billed according to the tariff selected by the homeowner. As mentioned, two tariffs are available – TOU-Domestic and Domestic Service – for demonstration homeowners to select.

The meter installation process would begin with the selection of the control community homes and informing the SCE field engineer of the addresses and construction completion sequence of the demonstration homes. The SCE engineer would meet with the SCE track planner to determine the customers that would be assigned a TOU meter and would process the meter service request and schedule the customer with the metering service organization. The SCE Customer Service Business Unit billing group then would place these customers on the appropriate tariff.

The control homes would automatically be placed on the normal domestic tariff. The demonstration homeowners would be asked to select a tariff. The meters for both homes would be the same regardless of the tariff schedules selected. The project team would work with K Street East LLC sales force to explain this procedure and inform the demonstration homeowners of their tariff choices. SCE also prepared a report outlining the steps that the customer needed to follow.

When the homes at O Bel Sole did not sell, and Phases Two and Three of the demonstration homes were indefinitely delayed, SCE discontinued its plan for installing TOU meters and circuit monitoring.

## **7.3. Task 7 Conclusions and Recommendations**

### **7.3.1. *Conclusions***

The project team suggests two general conclusions:

- Before a home with a PV system can be connected to the SCE grid system, various rules and tariffs must be followed. These can be extremely complicated and confusing to the homebuilder and homeowner.
- While the full plan of installing and tracking TOU meters and circuit monitors was never completed, it is evident that there are many potential distribution issues with grid-tied communities such as O Bel Sole that should be identified and researched by the utility. The full report of this research is referenced in Appendix VII.

### **7.3.2. *Recommendations***

- Utilities should work to simplify the steps required for net metering and the interconnection requirements for residential PV systems. In addition, they should consider monitoring distribution circuits for existing near-ZENH communities to identify potential problems with connecting solar home communities such as O Bel Sole to their system.
- Homeowners with PV systems need to be fully informed and guided through the utility application process to ensure they receive the maximum energy savings on their utility bills.



## **8.0 Task 8 ZENH Near-Term Cost Reduction Opportunities**

### **8.1. Task 8 Approach**

The goal of this task was to develop opportunities to reduce the cost of the optimized homes. The approach by the team included looking at the land entitlement process for ways to reduce time and therefore cost for development of these types of communities. The team also would work with the PV-partner to identify possible strategies to decrease installation costs and improve reliability and warranties.

The team had hoped to use information from the demonstration project to improve the optimized home designs and PV systems for potential deployment programs. They also planned to work with mortgage companies to improve financing processes.

ConSol would work to identify near-term cost reduction opportunities, and the rest of the project team would provide support.

### **8.2. Task 8 Outcomes**

The slow housing market coupled with sub-prime lending and mortgage issues drastically affected the ability to complete Task 8. With direction from the Commission contract manager, the project team narrowed its focus to one deliverable, a report offering a more thorough understanding of the land entitlement process and possible strategies and incentives therein to encourage sustainable development. The other activities for Task 8 were not conducted.

For the report, the project team studied the general plan and land entitlement processes, investigated incentives currently used during land entitlement to further sustainable homes and communities, and surveyed stakeholders involved in land entitlement to gain insights for additional incentives.

### **8.3. Task 8 Conclusions and Recommendations**

#### **8.3.1. Conclusions**

The land entitlement process is defined as the series of predevelopment activities that take place as plans are submitted to the city, county, state, and federal governments to secure the necessary approvals and permits to develop property for a desired use. Within this process lies the potential to direct stakeholders to the design and construction of sustainable homes and communities. While numerous incentives for builders and homeowners exist for features of physical construction, such as high-efficiency windows or air conditioning systems, few economic signals exist at the local jurisdictional level during early critical stages of securing approvals for developing land.

California's state government has moved ahead with aggressive initiatives to address and encourage green building, energy efficiency, renewable energy, and the reduction of greenhouse gas emissions in the residential sector.<sup>44</sup>

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<sup>44</sup> While this section describes activities at the state level, California's local municipalities and investor- and publicly owned utilities have also developed their own initiatives in this arena. For a list of California incentives for renewables and efficiency available in these sectors, see the Database for State Incentives for Renewable Energy at [www.dsireusa.org](http://www.dsireusa.org).

Fortunately, California currently has significant drivers pointing the state and the development community in the direction of better land use planning that is meant to contribute to reduced GHG emissions.<sup>45</sup> These drivers, however, do not appear to be tied to any strong economic signals to direct the development community to plan very early to build more sustainable homes and communities. In the absence of such economic signals, significant barriers remain. Barriers that were identified by surveying stakeholders included 1) first costs, 2) split incentive dilemmas, 3) potential impacts on land values, 4) impediments at the local jurisdiction level, 5) the role of the utilities, and 5) other uncertainties.

Based on stakeholder input, potential land entitlement incentives of interest include the following:

- Expedited permitting of projects seeking entitlement frees up capital and reduces carrying costs incurred as a result of an investment position. Jerry Yudelson of Yudelson Associates, a green-building consulting firm, states that given the complexity of the California regulatory environment, coupled with what can be the roller-coaster nature of the land entitlement process, of primary value to investors and developers is certainty of outcome such that time to market is expedited. This mitigates capital risk for developers as uncertainty of outcome leads to capital being tied up indefinitely.<sup>46</sup> Most incentives currently in place reward fast tracking of building permits but not necessarily permits to secure any entitlement approvals.
- Impact fees, or development fees, are expenditures that developers are required to make as a precondition to final map approval. Impact fees are generally used to finance roads, schools, affordable housing, transit systems, and other projects and services within municipalities. The fees are frequently passed on by developers to purchasers in the price of new buildings or property and, therefore, increase the cost of housing and decrease the profitability and potential competitive advantage of a particular project.<sup>47</sup>
- A new and emerging concept is incentives for a solar subdivision that could possibly tie the entire neighborhood or subdivision to the installation of energy-efficiency measure and solar PV. Incentives, both financial (deferral of fees, fee credits, lower property tax assessments for homeowners, etc.) and non-financial (expedited project permitting) could be further supported with streamlining of paperwork and verification and monitoring.
- Energy efficiency and renewable energy incentives could take a more holistic approach to embrace energy use reductions in master-planned communities.

The full report of this research is referenced in Appendix VII.

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<sup>45</sup> See Introduction.

<sup>46</sup> Per phone conversation with Jerry Yudelson on 07/08/08. See also Yudelson Associates at <http://greenbuildconsult.com/>.

<sup>47</sup> See National Association of Realtors, "Field Guide to Development Impact Fees" at <http://www.realtor.org/library/library/fg805>.

### **8.3.2. Recommendations**

In order to adequately address current barriers, gauge the effectiveness of incentives already in place, and assess the potential value of incentives not yet formally addressed in the new residential sector, the Commission should form a formal advisory committee with representatives from key stakeholder groups within the new residential sector. The goal of this advisory committee should be to provide the Commission with strategic input and feedback on the following questions:

- What financing strategies might help lessen the perceived risks associated with the investment in sustainable homes and communities?
- What does a stable financial environment look like that would support the design and construction of sustainable homes and communities?
- What are the most opportune stages of the land entitlement process to best address the design and construction of sustainable homes and communities (i.e., general plan, specific plan, development agreement, etc.)? Why?
- At which critical stages of the land entitlement process might local communities, in conjunction with the development community, best incentivize the design and construction of sustainable homes and communities? What does this incentive look like? Why?
- What can be done to address any barriers currently in place?
- What kind of policy frameworks would support these efforts?
- What are the perceived impacts of the Governor's Office of Planning and Research (OPR) recent Technical Advisory addressing GHG emissions and climate change for plans and projects undergoing review and approval during the California Environmental Quality Act (CEQA) review process? How can these impacts be best addressed? How can this process be used to create value?
- What kind of local jurisdictional practices would best support these efforts?



## 9.0 Glossary

Specific terms and acronyms used throughout this work statement are defined as follows:

Acronym	Definition
AEC	Architectural Energy Corporation
AFUE	Annual Fuel Utilization Efficiency
BECT	Builder Energy Code Training (BII Program)
BII	Building Industry Institute
BIPV	Building-Integrated Photovoltaics
BIRA	Building Industry Research Alliance
CBIA	California Building Industry Association
CEEP	Community Energy Efficiency Program (BII Program)
CPR	Critical Project Review
CPUC	California Public Utilities Commission
DAS	Data Acquisition System
DOE2	US Department of Energy - Energy Performance Modeling Software
EIR	Environmental Impact Report
ESCO	Energy Service Company
IECC	International Energy Conservation Code
ICF	Insulated Concrete Foam
IEA	International Energy Agency
IOU	Investor-Owned Utility
kWh	Kilowatt-hour
M&V	Measurement & Verification
MW	Megawatt
MWh	Megawatt-hour
OIR	Order Instituting Ratemaking
O&M	Operation & Maintenance
PAC	Project Advisory Committee
PV	Photovoltaic
SCE	Southern California Edison
SEER	Seasonal Energy Efficiency Rating
SIP	Structural Insulated Panel
T-Mass	Thermal Mass Wall System
TMY2	Typical Meteorological Year Data Set 2
TOU	Time of Use (electricity rate)
UCC.1	Uniform Commercial Code (Financing Statement)
W	Watt
ZEH	Zero Energy Home (US DOE Program)
ZENH	Zero Energy New Home
ZPC	Zero Peak Community



## **Appendix I: Builder Notes**

Additional efforts of the project team to gain a builder-partner commitment are summarized below.

### ***Various Builders Considered***

July through September, 2005 – various members of the PIER project team communicated with multiple builders.

- Victoria Homes was interested in discussions for Victorville (CZ 14) and in Highgrove in Riverside County (CZ10). Rob Hammon talked with them.
- Lennar Homes held discussions with Steve Galanter, Rob Hammon, and Charlene Langland (with Sharp) regarding opportunities in the Great Park development with the City of Irvine. The timeline for this project seemed too far in the future and Lennar was cautious about the ZENH concept.
- Sharp Solar approached William Lyon Homes, Brookfield Homes, and several others to no avail. These companies either did not have projects that could be altered in time to meet the timelines needed or had no appetite for doing something different.

### ***Pacer Homes***

September 14, 2005 – Don Frey reported on meeting with Pacer Homes. Three individuals from Pacer, including Erik Paine, attended the meeting. Pacer seemed receptive to the presentation by the project team (Don Frey, Rob Hammon, Charlene Langland, Steve Galanter, Chris Geltz). Doug Koerber with Indy Mac Bank also attended. The Pacer development under consideration had average home sizes of 2,000 to 2,500 square feet in the Chino (CZ 10) College Park subdivision.

After meeting with the PIER project team, Pacer went through a cost benefit analysis based on the proposal and meet with the President of the company. They provided a decision not to go forward with us.

### ***Pardee Homes***

November 10, 2005 – Pardee signed a Memorandum of Understanding (MOU) with AEC to participate in the program after several weeks of discussions with Joyce Mason (Pardee Vice President of Sales and Marketing) and presentations to the Pardee Executive Committee. The development is a Santa Clarita development (CZ 9) and construction was due to begin in April 2006. Homes sizes were 2,800 to 3,500 sq. ft.

April 25, 2006 – Joyce Mason sent the following e-mail regarding Pardee's decision to not participate.

"I am very sorry to report that Pardee Homes has had to make a difficult business decision to cease our participation in the PIER ZENH program for now. The marketplace is quite challenging at this point and our Management team feels that we will not be able to recoup the full cost of the program. We will however, market these homes in our Living Smart program and fold the program as designed into our options program."

“While it is unlikely that we will be able to sell as many ZENH houses as was mandated in the PIER program, we will, no doubt, sell some, and we will make the models a showcase for the features recommended. I thank you all for your patience and dedication as we have tried to work through the various challenges that have come up. One significant lesson that Pardee will take away from this is the value of one-coat stucco. All homes in these two neighborhoods will be built with this process and will be much more energy efficient thanks to this addition.”

“I know you will find another builder who will jump at this chance. Best of luck to all of you as you move to make energy efficiency and solar something that more people can have in their homes.”

### ***Clarum Homes***

June 6, 2006 – Clarum Homes signed a MOU with AEC. The Clarum Homes project would have been part of the Two Bunch Palms Development by John King Ventures, located in Desert Hot Springs (CZ 15). Square footage for the homes is 1,400 to 1,800.

November 6, 2006 – John Suppes informed AEC of the decision not to move forward and provided the following comments.

- Significant delays – King Ventures (developer) ran into problems with the archeology of the area; group representing the Indians banded together and the Environmental Impact Review was delayed and just recently published.
- Purchase agreement between Clarum and King has expired.
- Entitlements delayed until 2007 and market declines in housing have caused Clarum to cancel the contract and decline to buy the lots.
- Clarum may try to do a smaller project and renegotiate with King in the future.
- He said that many California housing projects may be delayed or changed because California is in a steep decline on housing. The housing market is much worse than what you read in the paper, which is usually news that is 3 to 6 months old.
- Many builders are selling graded and finished lots rather than building houses.
- Finally, John apologized as he thought things would go smoother. The bottom line is that pushing the Two Bunch Palms development into next year compromises his plans.

### ***Other Builder Considerations***

November 28, 2006 – A conference call was scheduled for November 29 for the project team to discuss options for signing builders. Key issues were projects must be within the SCE territory, the number of homes (75) built is important, and the timeline of the project is crucial. The team considered options for working closer with the New Solar Homes Partnership and possibly multiple builders.

- Steve Galanter revisited options for the Great Park development, city of Irvine. The timeline for Lennar Homes to build houses was still 18 to 24 months in the future.
- Matt Brost with Power Light had some options that he had mentioned to Don Frey and Chris Geltz, but the options did not surface.
- Rob Hammon reviewed options with other builders.

- Mike Gordon had alternative avenues and ideas about offerings, but to no avail.
- Chris Buntine and Jonathan Budner with SCE had ideas to offer, again to no avail.

### ***Final Builder***

December 9, 2008 – From spring 2007 through summer 2008, K Street East LLC was the final builder that agreed to participate with the project team. K Street East LLC is owned by Jennie Stabile, who has had a long history in the real estate business. She has a long list of credits as the first woman to hold a number of positions in the real estate world. She has built apartment buildings, converted apartments to condos, built single-family homes, and has sold as many as 52 homes in one month.

Stabile wanted to build the first solar community in Lancaster, California. She contracted with a builder, David Byrne, and his son, Shannon. With over 40 years experience, Byrne & Byrne build commercial, customs, multi-family, and work with investment groups throughout Antelope Valley in California. They are Antelope Valley's first production green/solar builder.

Additional information about this builder and the lack of homes sales at O Bel Sole is provided within the main body of the final project report. Of 41 homes, two had sold by December 2008. Two homes would not provide the quantity of energy data and homeowner information required by this research project for utility impact analysis or comparison to conventional homes.



## **Appendix II: Financial Summary of O Bel Sole Homes**

This financial summary was to be used as an information resource for sales agents for O Bel Sole, not a handout for potential homeowners. Rates or savings would not be quoted as actual savings. Savings were projections based on average climate/temperature conditions, assumed operating behavior, and projected systems operations. Actual costs/benefits would be most dependent on the occupant's behavior.

### ***Benefits***

- Amortizing the combined costs of energy efficiency features, rebates, credits and operating savings, homeowners could expect to save approximately \$100 per month by purchasing a Model C, O Bel Sole home.
- Homeowners can expect to see a reduction in electricity of up to 70 percent annually.
- Homeowners can expect to see a reduction in gas up to 20 percent annually.
- Combined reductions in utility bills (gas and electricity) are expected to be up to 60 percent annually.

### ***Key Notes***

- Homeowners have a choice of rate plans with Southern California Edison. Their options include the standard Schedule D plan, Time of Use D-1 plan, or Time of Use D-2 plan. It is the homeowners' responsibility to understand these plans and choose which plan would be best for their energy usage profile. The homeowners' behavior can have the most effect on use and rates. The lowest rates in this model were attained using SCE's Schedule D rate schedule.
- Savings will vary throughout the year based on weather and use patterns.

### ***Assumptions***

- Comparisons are made between a Model C, O Bel Sole house using SCE Schedule D and a similarly sized, similarly equipped house that meets the California Title 24 requirements using SCE Schedule D. Actual utility bills are based on utility-designed rate schedules. These rate schedules can change at any time, which would change the cost/benefit of the home's features.
- There is likely to be some loss in system efficiency over time, estimated to be 0.5 percent per year.
- Additional energy efficiency features are assumed to be financed over 30 years at 6.75 percent.
- This model assumes a net energy use at the end of each day. If the home produced more energy than it used on a given day or during a given billing cycle, different rate structures will apply, and different outcomes will result.



## Appendix III: Homeowner Survey

The research team prepared the following survey to be used when the optimized homes were occupied. Homeowners would be surveyed to gain qualitative information about living in the demonstration homes. A second set of homeowners that lived in comparable homes that were built only to Title-24 standards also would be surveyed. Due to the lack of sales and occupied homes at O Bel Sole, the surveys were not performed.

### *PLEASE COMPLETE AND RETURN THIS QUESTIONNAIRE*

(Adult members of your household may wish to complete this questionnaire together.)

Adding your name to this questionnaire is optional

#### **Pre-Occupancy Household Questionnaire Purchasing a High-Performance Home with a Solar Electric System**

1. Is this the first home you have purchased?

- ☐ Yes  
☐ No

2. When you were looking for your new home, did you also visit existing resale housing?

- ☐ Yes  
☐ No

3. When you were looking for your new home, did you also visit other new home communities in the area?

- ☐ Yes  
☐ No

4. On a scale of 1 to 10, how concerned were you about energy costs at the time you purchased your new home?

Not at all concerned					Very concerned				
1	2	3	4	5	6	7	8	9	10

5. How important were each of the following features in your decision to purchase your new home?

	Not at all important	Very important
a. Closeness to work	1 2 3 4 5	
b. Freeway access	1 2 3 4 5	
c. Access to services, shopping, etc.	1 2 3 4 5	
d. Great view	1 2 3 4 5	
e. Safe area/secure feeling	1 2 3 4 5	

- |                                     |           |
|-------------------------------------|-----------|
| f. Quality of schools               | 1 2 3 4 5 |
| g. Familiarity with the area        | 1 2 3 4 5 |
| h. Closeness to family/friends      | 1 2 3 4 5 |
| i. Closeness to parks/playground    | 1 2 3 4 5 |
| j. Desirability of the area         | 1 2 3 4 5 |
| k. Overall home value               | 1 2 3 4 5 |
| l. Investment potential             | 1 2 3 4 5 |
| m. Builder discount/incentive       | 1 2 3 4 5 |
|                                     |           |
| n. Builder reputation               | 1 2 3 4 5 |
| o. Helpfulness of sales staff       | 1 2 3 4 5 |
|                                     |           |
| p. Neighborhood quality             | 1 2 3 4 5 |
| q. Exterior designs                 | 1 2 3 4 5 |
| r. Community "feeling"              | 1 2 3 4 5 |
|                                     |           |
| s. Energy-efficient home            | 1 2 3 4 5 |
| t. Solar electric system            | 1 2 3 4 5 |
| u. Entire energy-efficiency package | 1 2 3 4 5 |

v. Other (please specify) \_\_\_\_\_

6. Now, please go back over the list above and write in below the **letters** of the three features that we most important to you when you decided to purchase your home:

\_\_\_\_\_ Most important

\_\_\_\_\_ Second most important

\_\_\_\_\_ Third most important

7. How important were each of the following **home** features in your decision to purchase your new home?

- |                                 | Not at all<br>important | Very<br>important |
|---------------------------------|-------------------------|-------------------|
| a. Architectural Design         | 1 2 3 4 5               |                   |
| b. Size/square footage          | 1 2 3 4 5               |                   |
| c. Floorplan/layout             | 1 2 3 4 5               |                   |
| d. Number of bedrooms           | 1 2 3 4 5               |                   |
| e. 3-car garage                 | 1 2 3 4 5               |                   |
| f. Kitchen features             | 1 2 3 4 5               |                   |
| g. Large closets/pantries       | 1 2 3 4 5               |                   |
| h. Lot size                     | 1 2 3 4 5               |                   |
| i. Quality of construction      | 1 2 3 4 5               |                   |
| j. Spaciousness/openness        | 1 2 3 4 5               |                   |
| k. Quality or sense of light    | 1 2 3 4 5               |                   |
| l. Standard features            | 1 2 3 4 5               |                   |
| m. Availability of many options | 1 2 3 4 5               |                   |
| n. Quiet neighborhood           | 1 2 3 4 5               |                   |

o. Other (Please specify) \_\_\_\_\_

8. How did you first hear about the O Bel Sole development?

- ☐ Driving by
- ☐ Friends, relatives, acquaintances
- ☐ Newspaper ad or article
- ☐ Website
- ☐ TV or radio
- ☐ Previous experience with the builder
- ☐ Other (please specify) \_\_\_\_\_

9. How satisfied were you with the sales staff in providing you with accurate and adequate information to assist you with your home purchase decision? (***Please circle one response.***)

Not at all satisfied							Very satisfied		
1	2	3	4	5	6	7	8	9	10

10. How satisfied were you with the sales staff in providing information on the energy efficiency and solar energy aspects of your home? (***Please circle one response.***)

Not at all satisfied							Very satisfied		
1	2	3	4	5	6	7	8	9	10

11. When you were looking for your new homes, how well informed would you say you were about energy efficiency and solar energy features? (***Please circle one response.***)

Not at all informed							Very informed		
1	2	3	4	5	6	7	8	9	10

12. How well informed would you say you are now? (***Please circle one response.***)

Not at all informed							Very informed		
1	2	3	4	5	6	7	8	9	10



## Appendix IV: Homeowner M&V Agreement

### ENERGY USE METERING AGREEMENT

The period of this Agreement starts on \_\_\_\_\_ and terminates on \_\_\_\_\_.

The parties to this Agreement are:

Architectural Energy Corporation ("AEC")  
2540 Frontier Avenue, Suite 201  
Boulder, Colorado 80301

and

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ ("Homeowner(s)")

The work performed by AEC under this Agreement is funded by the California Energy Commission ("CEC"). It involves installing energy meters and temperature sensors to monitor the performance of selected equipment and energy systems in Homeowner's residence ("Residence") located at:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

The parties agree as follows:

#### **A. Introduction**

The goal of this Energy Use Metering Project is to investigate the energy efficiency of residences constructed to qualify for the California New Solar Homes Partnership by metering the energy use of electric appliances, heating and cooling systems, and measuring temperatures in the attic and in the first and second floors, and providing comparative energy use analyses for publication under AEC's contract with the CEC. The results of the research will be used to develop informational materials and demonstrate the advantages of improved energy efficiency in California homes. Data from Homeowner's Residence will not be individually identifiable in the published information materials.

The duration of this Agreement and collection of data is expected to be about one year, but may be more or less as agreed upon by the parties.

#### **B. Definitions:**

1. "California New Solar Homes Partnership" means the program sponsored by the CEC.
2. "Project Personnel" includes:
  - a) employees of AEC,
  - b) agents, contractors, or consultants hired by AEC, and
  - c) employees of, and agents, contractors, or consultants of the CEC.
3. "Data Acquisition System", or "DAS", means all components which are used to meter appliances and systems, including data loggers, sensors, meters, wireless modem, wire, associated hardware, locking flush mounted metal cabinets, and other equipment which are provided by AEC. Portions of the Data Acquisition System may be installed for the entire duration of the Agreement. Other portions may be installed and removed during the period of the agreement.

4. "Home Energy Use Display" is a flat screen information display located on the first floor near the thermostat. It is provided to Homeowner to view the overall electrical use of the Residence and its solar electric production.

**C. Data Acquisition System**

1. The DAS shall remain the property of AEC unless otherwise noted in this Agreement. AEC shall install the DAS at its own expense, including a wireless modem for data collection. The primary location for the DAS is in a pair of locked cabinets in the Residence garage. The location for the wireless modem antenna is on the eave or roof of the Residence. AEC has exclusive use of the wireless modem for its data acquisition and maintenance of the DAS.

2. AEC's Personnel shall have access to the Residence for the purposes of installing, removing, operating, and maintaining the DAS. Access shall be during times as mutually agreed upon from time-to-time, for the full period of this Agreement.

3. AEC shall identify to Homeowner its designated personnel and representatives with a need to enter the Residence and shall use its best efforts to minimize interference and disruption to Homeowner's use and enjoyment of the Residence.

4. The DAS shall be removed from the Residence by AEC no later than the last day of this Agreement unless otherwise agreed upon in writing by the parties. All cabinets in the garage, all data acquisition wiring embedded in the Residence, and temperature sensors will remain in place and may be used by Homeowner after the Agreement period has expired.

**D. Home Energy Use Display**

1. The Home Energy Use Display is provided as part of the Residence and belongs to the Homeowner. It displays electrical production and use from a website maintained by the solar electric system manufacturer, SunPower. During the course of the Agreement, the displayed information is obtained through the internet access provided by AEC for data retrieval. After expiration of the Agreement, Homeowner may continue to use the Home Energy Use Display by providing an internet connection for the Display. Access for connection can be made through a modem provided by the Homeowner.

**E. Rights in Data and Information**

1. AEC and the CEC shall have the right to publish, translate, reproduce, deliver, perform, use and dispose of in any manner any and all data collected during the metering project in a form that does not identify Homeowner or Residence. By signing this Agreement, Homeowner waives all rights with respect to all collected data. All available data from Residence shall be provided to the Homeowner at no cost upon request.

2. AEC and the CEC do not warrant that data collection will be continuous or complete, or that the data will be useful for any other purpose than that for which it was collected. Any data that may be collected during the period of this Agreement are not necessarily comparable with any other data or analysis performed by others.

**F. Homeowner's Obligations**

1. Homeowner agrees to exercise reasonable care to prevent loss of, or damage to, the DAS or other AEC equipment installed on or in the Residence. Homeowner agrees not to disrupt DAS operation by turning off the electrical power to the DAS or otherwise interfering with its operation.

2. Homeowner agrees to participate in two brief surveys to be conducted under AEC's direction. The first survey will be conducted shortly after Homeowner moves into the Residence. The second survey will be conducted six to 12 months after Homeowner moves in.

3. Homeowner agrees to notify AEC within 14 calendar days if, during the Agreement period:

- the Residence is unoccupied for more than seven calendar days,
- Homeowner leases the Residence to others,
- the number of occupants changes,
- large electrical appliances (refrigerator, oven, dishwasher, home entertainment system, cooling and/or heating system components, solar electric system, etc.) are added, removed, or modified, or
- there are other significant changes in use of the Residence that may affect its electrical energy profile.

**G. Payment for Participation in Project**

1. In consideration of Homeowner's participation in the project and fulfillment of the obligations stated in Section G. Homeowner's Obligations, AEC will pay Homeowner:

- a. \$50.00 after signing this agreement,
- b. \$50.00 after participating in the first survey,
- c. \$50.00 after participating in the second survey, and
- d. \$50.00 after completion of the monitoring period.

**H. Miscellaneous**

1. Each party designates the undersigned individuals to represent them in transactions and communications regarding this Agreement. Notice of delegations of authority or responsibility will be provided to the other party in writing at appropriate times.

2. Notices under this agreement may be made by email, by telephone confirmed by email, by letter delivered via US Postal Service, or overnight delivery service. Notices sent via mail or overnight delivery service shall be sent to the respective addresses of AEC and the Homeowner shown above.

3. AEC may terminate this agreement if its contract with the CEC is terminated for any reason.

4. This agreement is binding upon each party's successors and assigns.

By the signatures of their respective representatives, the parties hereby agree to the terms and conditions stated herein. Prior oral and written agreements are superseded in their entirety by this Agreement.

For  
Architectural Energy Corporation

For  
Homeowner

\_\_\_\_\_  
Vernon Smith  
Project Manager

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



## Appendix V: Antelope Valley Press

### ***'Green' homes sprout in Valley***

This story appeared in the Antelope Valley Press on Thursday, October 11, 2007.

By GABRIELA GARAY  
Valley Press Staff Writer

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LANCASTER - O Bel Sole Estates at East Ave. K and 25th Street East has become the first development in Southern California to participate in the California Energy Commission's New Solar Homes Partnership, introducing three model homes for a community of 41 solar-paneled and environmentally friendly homes.

Development owner Jennie Stabile of K Street East LLC unveiled the model homes Oct. 4, with California Energy Commission assistant executive director Claudia Chandler, SunPower Corp. account manager Addison Marks, Southern California Edison chief architect Gregg Ander and other dignitaries in attendance.

The solar-powered, futuristic houses incorporate "green" materials throughout. The development is the first in the Antelope Valley for K Street East, which has built communities in Burbank, Chatsworth and Canoga Park.

Chandler said the sleek, almost invisible solar panels will send power back to the utility. "We were interested in this development because it integrates the solar panels into the roof," she said. "People will save up to 60 percent when the sunshine generates electricity through the panels. If it is not used, it goes into the utility; then during the night you have a credit. At the end of the year, you may save more money. These homes are anywhere from 35 percent to 40 percent more efficient than what the state requires. These houses will consume less energy than other houses."

The O Bel Sole Estates have solar panels integrated into the roofing tiles, water-efficient landscaping, weather-based irrigation controls, engineered wood products, nontoxic paints and tankless water heaters. The solar panels are designed to blend into the rest of the roof. Stabile said, "There were no integrated solar panels into roofs before. They finally came up with the integrated roof tiles and energy efficiency was more available, which is why we decided to build these homes now."

K Street East offers three two-story floor plans in the community: the Rimini at 2,800 sq. ft., the Siena at 3,218 sq. ft. and the Brescia at 3,533 sq. ft.. The plans are reversible for a total choice of six designs.

Chandler said that O Bel Sole is what the California Energy Commission wants, and the homes are an investment in California. "We want to see green homes," Chandler said. "There are a lot of people moving to California. If we can build homes like this, it will alleviate some of the burden that we cause on the environment. We encourage this type of development. It can make a difference in the way we impact our environment."

"These houses come with a monitoring system integrated into the home" said Addison Marks, builder account manager for SunPower. "They show how much energy you are using and how much energy you are not using."

Chandler said, "These homes are great. People will also enjoy the great savings because these homes have a lot to offer, such as triple-pane windows. I would love to see more builders build this type of home."

Stabile said the energy-efficient homes are priced "about the same as homes that don't have the solar energy panels." She said they start at \$499,950.

Although O Bel Sole is the first to get on the market, Marks said his company is installing their solar panels all over the state. "We have more than 50 different construction sites under development," he said.

"I call this home 'the home of the future' "Stabile said, "The Antelope Valley reminded me of the San Fernando Valley in the 1950s. This beautiful valley was where I wanted to develop and build homes of the future. Live better, for less, live green."

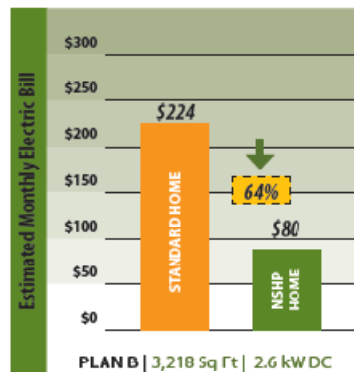
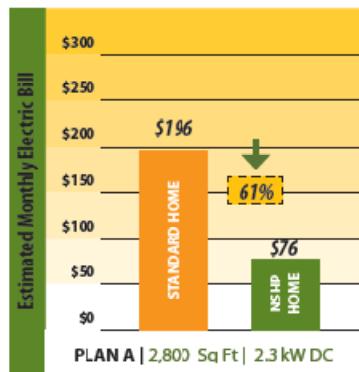
ggaray@avpress.com

## Appendix VI: Benefits and Features Collateral



### O'Bel Sole! Homes, Presented by K Street L.L.C., Provide Superior Energy Performance

- Increased insulation (R-21 wall, R-49 attic, ducts buried in attic)
- Radiant barrier
- 95% high efficiency furnace
- 16 SEER air conditioner with TXV
- Engineered Heating, Ventilating and Air Conditioning (HVAC) system
- High-performance triple-pane windows
- Fluorescent lighting
- Tankless water heaters
- 2.3-2.8 kW DC photovoltaic (solar electric) system
- Third-party testing and verification of energy features



Calculations of total savings were prepared by ConSol and are based on data from the U.S. Department of Energy. Actual savings may vary, depending on individual energy use. Estimated energy use assumes average weather, thermostat settings, and quantities of hot water for a typical household. Energy costs are based on typical local energy rates. The amount of energy (kWh) produced by the PV system will depend on weather conditions and the amount of sunlight hours available. Although every effort has been made to provide accurate information, this information does not constitute a warranty, expressed or implied, about the energy efficiency or operating costs of these homes.

**Live Better.** *O Bel Sole! is a new development, presented by K Street East, L.L.C., consisting of 41 solar-electric powered, energy-efficient and green homes. O Bel Sole! homes can help homeowners save up to 60% on utility bills as well as help reduce their impact on the environment.*

## KEY FEATURES

<b>Appliances</b>	Energy Star®	<b>HVAC</b>	0.95 AFUE furnace 16 SEER (12.5 EER) AC
<b>Air Sealing</b>	Caulking and sealing measures ensure low air infiltration	<b>Water Heating</b>	Two tankless water heaters 0.82 energy factor Hot water pipe insulation
<b>Insulation</b>	R-21 wall insulation R-49 roof insulation (at attic) R-19 roof insulation (at furnace) R-30 floor insulation (above garage) Attic Radiant Barrier R-6 Insulated ducts buried in attic	<b>PV Solar</b>	Plan A 2.3kW DC Plan B 2.6kW DC Plan C 2.8kW DC
<b>Windows</b>	U-Factor : 0.20 Sliders; 0.16 Fixed 0.33 Patio; 0.40 French Door SHGG: 0.22 Sliders; 0.24 Fixed 0.34 Patio; 0.40 French Door	<b>Testing</b>	ComfortWise®



### Solar Performance Monitoring

This system enables home owners to view and chart their solar electric system energy production, environmental savings, and electricity usage in real time.



### Solar Electric System

Solar electric panels are beautifully integrated into the roof tiles of each home. This renewable source of energy provides approximately 42% of the electricity needed to power your home.

## Live Green.

### Green Features

- Water-Efficient Landscape
- Weather-Based Irrigation Controller
- Engineered Wood Products
- Low-VOC Paints
- Construction Waste Recycling

### Third-Party Testing and Verification by Certified Home Energy Rater

- Blower Door Testing for House Airtightness
- Duct Testing for Air Distribution Efficiency
- Verified Quality Insulation Installation
- Central A/C Refrigerant Charge Test

## KEY CONTACTS

### Building Industry Research Alliance (BIRA)

The Building Industry Research Alliance (BIRA) is a diverse coalition of over eighty industry partners committed to improving energy and resource efficiency in residential housing for the Department of Energy's Building America Program (BAP). The goal of BAP is to build marketable, cost-effective Net Zero Energy Homes across the country by 2020. BIRA, one of the six DOE teams, is led by ConSol.

www.BIRA.ws  
Steve Vang, Senior Consultant  
SVang@ConSol.ws  
209.473.5000



### California Green Builder (CGB)

The California Green Builder program saves energy, water, and resources—conserving resources, preserving the environment, and measuring the impact.

www.CAGreenBuilder.org  
Justin Dunning, Director  
JDunning@CAGreenBuilder.org  
866.340.8912



### ConSol

ConSol, an energy consulting firm, offers energy solutions for production builders and provides the ComfortWise family of energy efficiency programs including: ComfortWise, ComfortWise Green, and ComfortWise Zero Energy Neighborhoods.

www.ComfortWise.com  
Francene DuPre, National Sales Manager  
FDuPre@ConSol.ws  
209.473.5000



### Demand Responsive Emerging Technologies (DRET)

As part of the energy efficiency plan for each home, this development is also participating in Southern California Edison's (SCE) third party program, Demand Responsive Emerging Technologies, administered by ConSol. As part of this program, each home utilizes ducts buried in attic insulation, refrigerant charge verification and a verified low-leakage duct system. These proven technologies are being studied to help broaden their utility within the residential market.

Adam Neugebauer, Project Manager, ConSol  
ANeugebauer@ConSol.ws  
209.473.5000



### New Solar Homes Partnership (NSHP) initiative

The California Solar Initiative was approved by the California Public Utilities Commission (CPUC) creating a ten-year program to put solar on a million roofs in the state. The California Energy Commission will manage the New Solar Homes Partnership (NSHP) and will work with builders and developers to incorporate high levels of energy efficiency and high-performing solar.

www.solarcalifornia.ca.gov/nsdp/  
Claudia Chandler, Assistant Director  
mediaoffice@energy.state.ca.us  
916.654.4989

## **Appendix VII: Referenced Project Documents**

The project team prepared a number of reports as deliverables under this contract (#500-04-024). A list that includes both unpublished and published reports follows. All listed reports are available at [www.archenergy.com/pier/zenh-reports.html](http://www.archenergy.com/pier/zenh-reports.html).

### ***Unpublished Reports:***

- I. Design Process Case Study for the Demonstration ZENHs (Deliverable 2.1)
- II. Builder Design Guide for ZENH Designs California Climate Zones 8-13 (Deliverable 2.3)
- III. Commissioning Guidelines for Zero Energy New Homes (Deliverable 2.4)
- IV. Homes Designs for ZENH Demonstration (Deliverables 2.2 Original, 2.5 Updated)
- V. Market Models for the Zero Energy New Home Demonstration (Deliverable 3.2)
- VI. Builder and Contracting Training for Zero Energy New Homes (Deliverable 4.1)
- VII. In-Home Energy Display Selection, Installation, and Commissioning Report (Deliverable 4.2)
- VIII. Sales and Marketing Report (Deliverable 4.3)
- IX. M&V Protocol and Selection Process Report (Deliverable 5.1)
- X. Performance Evaluation Report (Deliverable 5.4)
- XI. Branding and Marketing Strategy (Deliverable 6.4)
- XII. Electrical Distribution System Impact Plan (Deliverable 7.1)

### ***Reports in the Process of Publication through the California Energy Commission:***

- XIII. “The Land Entitlement Process and Incentives for Sustainable Communities” (Deliverable 8.1) (to be posted to the Energy Commission’s website at [www.energy.ca.gov/2009publications/CEC-500-2009-089](http://www.energy.ca.gov/2009publications/CEC-500-2009-089)).